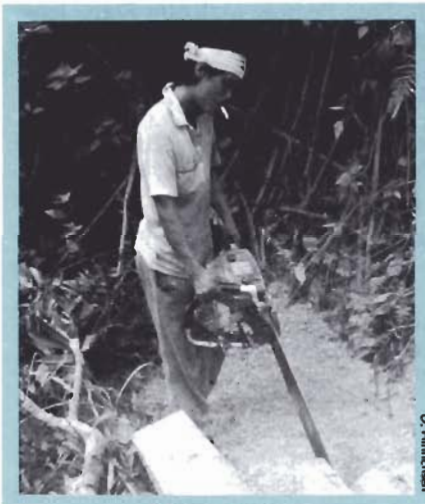
Population Reports



D. Hinrichsen

Highlights

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Population and the Environment

The Global Challenge

As the century begins, natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines afflict many areas. As the world's population grows, improving living standards without destroying the environment is a global challenge.

Most developed economies currently consume resources much faster than they can regenerate. Most developing countries with rapid population growth face the urgent need to improve living standards. As we humans exploit nature to meet present needs, are we destroying resources needed for the future?

Environment Getting Worse

In the past decade in every environmental sector, conditions have either failed to improve, or they are worsening:

Public health. Unclean water, along with poor sanitation, kills over 12 million people each year, most in developing countries. Air pollution kills nearly 3 million more. Heavy metals and other contaminants also cause widespread health problems.

Food supply. Will there be enough food to go around? In 64 of 105 developing countries studied by the UN Food and Agriculture Organization, the population has been growing faster than food supplies. Population pressures have degraded some 2 billion hectares of arable land—an area the size of Canada and the US.

Freshwater. The supply of freshwater is finite, but demand is soaring as population grows and use per capita rises. By 2025, when world population is projected to be 8 billion, 48 countries containing 3 billion people will face shortages.

Coastlines and oceans. Half of all coastal ecosystems are pressured by high population densities and urban development. A tide of pollution is rising in the world's seas. Ocean fisheries are being overexploited, and fish catches are down.

Forests. Nearly half of the world's original forest cover has been lost, and each year another 16 million hectares are cut, bulldozed, or burned. Forests provide over US$400 billion to the world economy annually and are vital to maintaining healthy ecosystems. Yet, current demand for forest products may exceed the limit of sustainable consumption by 25%.

Biodiversity. The earth's biological diversity is crucial to the continued vitality of agriculture and medicine—and perhaps even to life on earth itself. Yet human activities are pushing many thousands of plant and animal species into extinction. Two of every three species is estimated to be in decline.

Global climate change. The earth's surface is warming due to greenhouse gas emissions, largely from burning fossil fuels. If the global temperature rises as projected, sea levels would rise by several meters, causing widespread flooding. Global warming also could cause droughts and disrupt agriculture.

Toward a Livable Future

How people preserve or abuse the environment could largely determine whether living standards improve or deteriorate. Growing human numbers, urban expansion, and resource exploitation do not bode well for the future. Without practicing sustainable development, humanity faces a deteriorating environment and may even invite ecological disaster.

Taking action. Many steps toward sustainability can be taken today. These include using energy more efficiently; managing cities better; phasing out subsidies that encourage waste; managing water resources and protecting freshwater sources; harvesting forest products rather than destroying forests; preserving arable land and increasing food production through a second Green Revolution; managing coastal zones and ocean fisheries; protecting biodiversity hotspots; and adopting an international convention on climate change.

Stabilizing population. While population growth has slowed, the absolute number of people continues to increase—by about 1 billion every 13 years. Slowing population growth would help improve living standards and would buy time to protect natural resources. In the long run, to sustain higher living standards, world population size must stabilize.

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The Earth and Its People

As the 21st century begins, growing numbers of people and rising levels of consumption per capita are depleting natural resources and degrading the environment. In many places chronic water shortages, loss of arable land, destruction of natural habitats, and widespread pollution undermine public health and threaten economic and social progress (21, 30, 202). Many experts think that current trends cannot continue much longer without dire consequences (57, 122–124, 128, 158, 202, 249).

In most developed countries population is growing slowly or no longer growing at all, but levels of per capita consumption are so high that the environment is under pressure. Most developing countries face even greater pressures, however. Population is growing rapidly, while consumption is increasing as living standards improve. Every person has an equal right to achieve a high standard of living. But, if every person in the world consumed as much as the average American or Western European, the demand for natural resources would exceed nature's supply (222).

"There is no question that improving standards of living for the current poor of the world, plus providing for the billions still to come, will increase global demand for food, water, energy, wood, housing, sanitation, and disposal of wastes," writes Richard E. Benedick, former US assistant secretary of state responsible for population and environmental policies (11). One of the world's main challenges is practicing sustainable development—that is, improving living standards today without foreclosing the opportunities of future generations to meet their needs (227, 256, 258, 259, 264).

An Environmental Scorecard

In 1992, concerned about worsening environmental conditions, delegates to the UN Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, stressed the need for action. The Rio "Earth Summit" set specific goals for environmental improvements. Then in 1997 a Special Session of the UN General Assembly—popularly known as the "Rio Plus Five Conference"—met to assess progress toward these goals (9, 101, 127, 146, 223, 224, 232).

The conclusions were discouraging. In such sectors as land, freshwater, forests, biodiversity, and climate change, the 1997 UN assessment found that conditions either were no better than in 1992 or had worsened (223, 232).

Despite lower poverty rates, the number of poor people had increased—in large part because of rapid population growth in developing countries, as well as uneven development, and increasing concentration of wealth (222, 223, 227).

Arable land. At the beginning of the 1990s, about 560 million hectares of cropland worldwide were degraded, of a total 1.5 billion hectares. At the end of the decade about 610 million hectares were degraded (265). Soils can become degraded rapidly when they are overworked and thus become more exposed to erosion.

Freshwater. Worldwide, the percentage of the population with access to clean freshwater increased during the 1990s. Nevertheless, due to rapid population growth, currently an estimated 1.2 billion people lack potable water—20% more than in 1990 (222, 227, 261, 265). Also, about 3 billion people lack adequate sanitation facilities compared with 2 billion in 1990 (227, 261).

Forests. Half the world's original forest cover—over 3 billion hectares—has been lost, largely during the past five decades (25). Deforestation has accelerated since 1990. For instance, tropical forests declined from 1.7 billion hectares in 1990 to 1.4 billion in 1999 (263, 265).

Globally, about 16 million hectares of forest, an area roughly the size of Nepal, are cut, bulldozed, or burned each year. In the Brazilian Amazon the annual deforestation rate has increased by about one-third since 1992 (268, 269).

Biodiversity. Human activities already have pushed many plant and animal species into extinction. While no one knows the exact number, there is wide agreement that the rate of extinction will accelerate as population growth and development put more pressure on prime habitats of other species (163, 164).

Pollution. Air pollution, already a serious problem in many cities, is becoming worse as urban populations grow and the number of motor vehicles rises. Water pollution is a serious problem almost everywhere (220). Biologist Peter Vitousek and colleagues have warned that human numbers and

JHU/CCP

Motor vehicles clog the "beltway" around Baltimore. In developed countries high levels of per capita consumption are polluting the air and water and using up natural resources. Developing countries face environmental challenges as they seek to raise living standards in the face of rapid population growth.

Measuring Population's Impact

There is no easy way to measure the overall impact of human activities on the environment. Nevertheless, several approaches have been developed, as follows:

Environmental Resource Accounting

Environmental resource accounting attempts to place an economic value on "environmental goods and services" used—natural resources that conventionally have been regarded as free and used in common. These include unpolluted freshwater, clean air, ocean life, forests, and wetlands. A recent study by Robert Costanza of the University of Maryland estimated the total value of ecosystem services and products at US$33 trillion per year—an amount that exceeds the total value of the global economy as conventionally measured (US$29 trillion in 1998) (41, 163).

Some economists argue that the value of environmental goods and services should be incorporated into estimates of Gross Domestic Product (GDP), as are manufactured assets. Unlike manufactured capital, which depreciates in value over time, environmental capital (such as forests, fisheries, and unpolluted air and water) currently is not considered to depreciate, and no charge is made against current income as it is used. "A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these natural assets disappeared," notes Robert Repetto of the World Resources Institute (98, 192).

If natural resources were valued in the same way that manufactured assets are valued, it might help economies learn to use them more efficiently and to conserve them in order to assure continued use in the future. Such valuations also might help indicate the economic benefits of protecting the environment, as well as the ecological benefits. In other terms, instead of continuing to draw down their "environmental capital" until it is gone, economies could begin to live on its interest, maintaining the capital for use indefinitely in the future (90).

I = PxAxT

The equation I = PxAxT represents another effort to describe the overall impact of humanity on the environment. In the equation:

- **I** is environmental impact,
- **P** is population (including size, growth, and distribution),
- **A** is the level of affluence (consumption per capita), and
- **T** is the level of technology.

Despite its limitations—for instance, inability to assign actual values to each component or to depict changes in the factors over time—the equation is valuable. In particular, it emphasizes that developing countries with large and rapidly growing populations affect the environment, even though their levels of affluence may be low, while at the same time countries in the developed world with little or no population growth have a substantial environmental impact because consumption per capita is so high (54, 55, 92, 212).

The equation makes clear that slowing population growth is a key part of any strategy to reduce humanity's impact on the environment. For example, even if per capita resource consumption (A) declined or technologies (T) improved enough to reduce the environmental impact (I) of humanity by 10%, this gain would be wiped out in less than a decade because world population (P) is growing at over 1% per year (92, 240). Since per capita consumption of resources is expected to increase as living standards rise, protecting the environment requires more efficient production technologies, less waste, and ultimately a stable world population size (245, 247).

Ecological Footprints of Nations

In 1997, as part of the five-year review of environmental conditions following the Rio Earth Summit, the Earth Council of Costa Rica sponsored a major "Ecological Footprints of Nations" study. The chief researcher was Mathis Wackernagel of the University of Anahuac de Xalapa in Mexico.

Wackernagel's study calculated, nation by nation, the biologically productive areas needed to provide the resources consumed by the population and to absorb their wastes, given prevailing levels of technology. As Wackernagel explained, "Everybody has an impact on the Earth, because they consume the products and services of nature. Their ecological impact corresponds to the amount of nature they occupy to keep them going. In other words, we calculate the 'ecological footprints' of these countries" (249).

Wackernagel and his group calculated the ecological footprints of 52 nations containing 80% of the global population and accounting for 95% of the World Domestic Product. The researchers concluded that the world's people are using about one-third more of the earth's biological productivity than can be regenerated (249).

Carrying Capacity

The term "carrying capacity" refers to the number of people the earth can support. Logically, population growth must stop at some point, or the earth would become overcrowded and its resources eventually would be depleted. But what is this maximum human population?

This question has been debated since 1798, when English economist Thomas Malthus predicted that population growth inevitably would outstrip the food and water supply at some point. Since then, estimates of carrying capacity have varied a great deal depending on what assumptions are made about technology, consumption levels, and other factors that are not easily forecast (38). Some have even argued that the earth's carrying capacity may already have been exceeded in the sense that that the world could support only 2 billion people if the entire world consumed at the rate that Americans and Western Europeans consume (42).

While nobody can know how many people the earth could support, few would want to find out the hard way—by reaching this theoretical limit. Calculating the maximum number of people who could exist on earth seems less important than determining how resources can be used wisely and managed sustainably to improve living standards without eventually destroying the natural environment that supports life itself.

actions risk fundamentally disrupting nature's basic cycling of water, nitrogen, phosphorus, and carbon among the ecosystems. Largely by releasing carbon dioxide into the atmosphere and by destroying or altering biological resources, humanity is causing "rapid, novel, and substantial" changes to the environment (247).

Climate change. At the Rio Earth Summit in 1992, whether the global climate was changing was still a matter of debate. Since then, the evidence has mounted (see box, p. 16). In 1990 atmospheric concentrations of carbon dioxide—the main climate-changing gas—were measured at about 355 parts per million (135). In 1997 concentrations were measured at about 364 parts per million (233). Since 1950 carbon dioxide emissions have increased fourfold (21).

Poverty. During the 1990s the number of people in poverty increased by about 1 billion. In 1990 about 2 billion people were subsisting on the equivalent of US$2 a day or less (222). By 2000 that number had risen to about 3 billion—half of the world's population (236).

Population and Sustainable Development

Environmentalists and economists increasingly agree that efforts to protect the environment and to achieve better living standards can be closely linked and are mutually reinforcing. Slowing the increase in population, especially in the face of rising per capita demand for natural resources, can take pressure off the environment and buy time to improve living standards on a sustainable basis (92, 196, 245, 254).

Although it is not clear whether in the long run rapid population growth causes poverty, "it is clear that high fertility leading to rapidly growing population will increase the number of people in poverty in the short run and, in some cases, make escape from poverty more difficult," observes researcher Dennis A. Ahlburg (7). It is difficult to make investments for the future when resources are already fully used trying to keep up with the current needs of rapidly growing populations.

As population growth slows, countries can invest more in education, health care, job creation, and other improvements that help boost living standards (245). In turn, as individual income, savings, and investment rise, more resources become available that can boost productivity. This dynamic process has been identified as one of the key reasons that the economies of many Asian countries grew rapidly between 1960 and 1990 (144).

In recent years fertility has been falling in many developing countries and, as a result, annual world population growth has fallen to about 1.4% in 2000 compared with about 2% in 1960. The UN estimated recently that population is growing by about 78 million per year, down from about 90 million estimated early in the 1990s (243). Still, at the current pace world population increases by about 1 billion every 13 years. World population surpassed 6 billion in 1999 and is projected to rise to over 8 billion by 2025.

Globally, fertility has fallen by half since the 1960s, to about three children per woman (243). In 65 countries, including 9 in the developing world, fertility rates have fallen below replacement level of about two children per woman (224). Nonetheless, fertility is above replacement level in 123 countries, and in some countries it is substantially above replacement level. In these countries the population continues to increase rapidly.

About 1.7 billion people live in 47 countries where the fertility rate averages between three and five children per woman. Another 730 million people live in 44 countries where the average woman has five children or more (182).

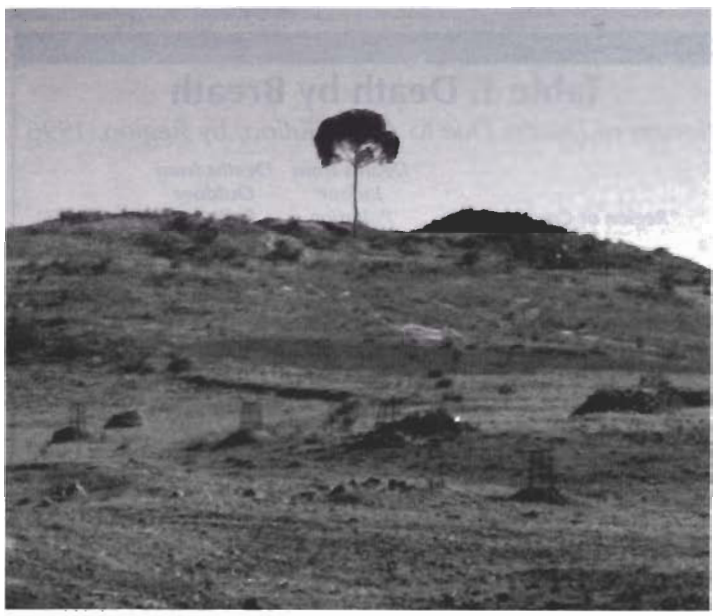
Almost all population growth is in the developing world. As a result of differences in population growth, Europe's population will decline from 13% to 7% of world population over the next quarter century, while that of sub-Saharan Africa will rise from 10% to 17%. The shares of other regions are projected to remain about the same as today (169).

As population and demand for natural resources continue to grow, environmental limits will become increasingly apparent (169). Water shortages are expected to affect nearly 3 billion people in 2025, with sub-Saharan Africa worst affected (82). Many countries could avoid environmental crises if they took steps now to conserve and manage supplies and demand better, while slowing population growth by providing families and individuals with information and services needed to make informed choices about reproductive health.

Family planning programs play a key role. When family planning information and services are widely available and accessible, couples are better able to achieve their fertility desires (133). "Even in adverse circumstance—low incomes, limited education, and few opportunities for women—family planning programs have meant slower population growth and improved family welfare," the World Bank has noted (27).

If every country made a commitment to population stabilization and resource conservation, the world would be better able to meet the challenges of sustainable development. Practicing sustainable development requires a combination of wise public investment, effective natural resource management, cleaner agricultural and industrial technologies, less pollution, and slower population growth.

Better resource management protects the environment and preserves nature's productive capacity. Stronger economies can afford to invest more in protecting the environment. Slower population growth can speed economic growth and conserve natural resources.



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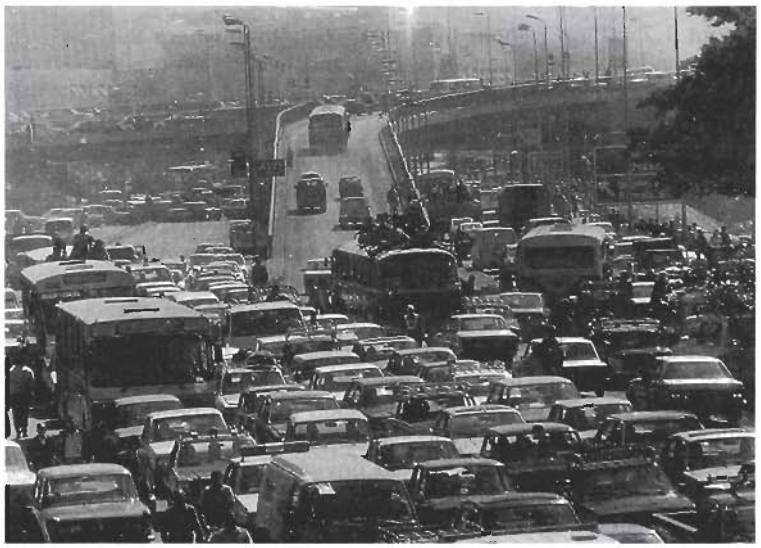
A solitary tree watches over a barren hillside. Around the world people are depleting forests, arable land, and water supplies. Can present needs be met while safeguarding resources for the future?



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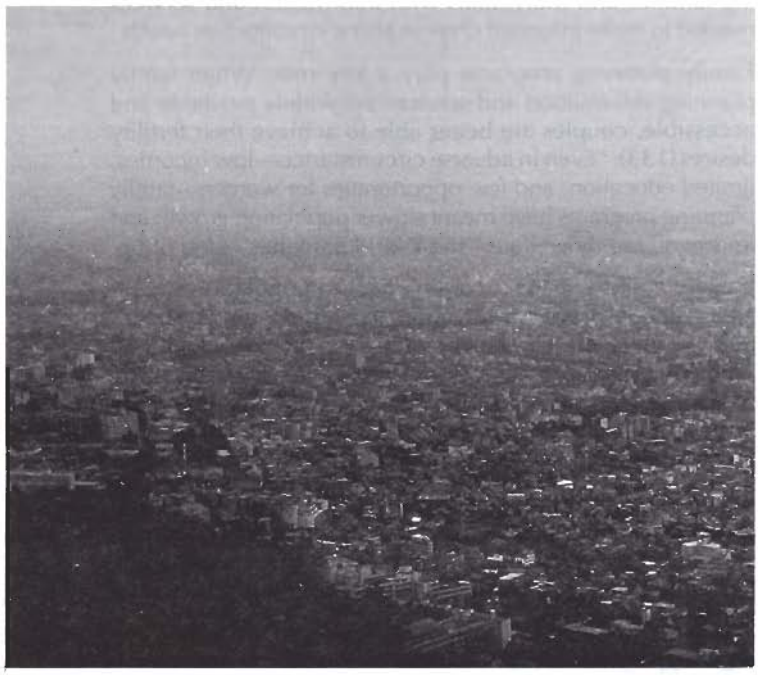

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Table 1. Death by Breath

Estimates of Deaths Due to Air Pollution, by Region, 1996

Region or Country	Deaths from Indoor Pollution	Deaths from Outdoor Pollution	Total
Asia			
China	373,000	70,000	443,000
India	589,000	84,000	673,000
Other Asian countries	403,000	40,000	443,000
Latin America & Caribbean	293,000	113,000	406,000
Sub-Saharan Africa	522,000	—	—
Arab states	—	57,000	—
Industrialized countries	32,000	147,000	179,000
Grand total	2,212,000	511,000	2,723,000

— Estimate not available

Source: United Nations Development Programme (UNDP), 1998 (227)

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Above: In Cairo thousands of cars, trucks, and buses sit in traffic.
Center: A pall of pollution hangs over the city of Bogota.
In many developing countries, atmospheric pollution is a serious hazard—responsible for at least 2 million deaths annually. Curbing outdoor and indoor air pollution would improve health substantially.

Pollution and Health Risks

Growing pollution poses mounting problems for public health. In virtually all countries studies identify health problems linked to environmental contaminants (31, 129, 130, 132, 142, 145, 151, 194, 197, 203, 206, 253, 272). Such studies have a long history. In 1855 John Snow published the results of his innovative study of the causes of cholera in London, attributing it to drinking water contaminated with raw sewage—marking the beginning of the field of epidemiology (218).

In developing countries today the old killers are still around —tuberculosis, malaria, and diarrheal diseases, among others—and now HIV/AIDS. But joining these as important causes of death and ill health are cancers and chronic diseases caused by industrial and agricultural chemicals and other pollutants in the atmosphere, soil, and water (193).

Lead, mercury, copper, arsenic, and other heavy metals used in industry have caused many deaths. A number of pesticides and other chemicals, known as POPs (persistent organic pollutants), which are used both in agriculture and in industry, can cause cancer and genetic abnormalities in humans.

Air Pollution

Air pollution kills an estimated 2.7 million to 3.0 million people every year—about 6% of all deaths annually (171, 227, 261). About 9 deaths in every 10 due to air pollution take place in the developing world, where about 80% of all people live (227) (see Table 1).

About 2.5 billion people, almost all in developing countries, suffer from high levels of indoor air pollution (200). Indoor air pollution is due to burning wood, animal dung, crop residues, and coal for cooking and heating. Most of the victims of indoor pollution are women and girls, who have primary responsibility for cooking and tending the house (227).

Outdoor air pollution harms more than 1.1 billion people, mostly in cities (196). The World Health Organization (WHO) estimates that about 700,000 deaths annually could be prevented in developing countries if three major atmospheric pollutants—carbon monoxide, suspended particulate matter, and lead—were brought down to safer levels (48, 261). The direct health cost of urban air pollution in developing countries was estimated in 1995 at nearly US$100 billion a year. Chronic bronchitis alone accounted for around US$40 billion (227).

In cities that lack pollution controls, millions of people are at risk from outdoor pollution. Densely populated and rapidly growing cities such as Bangkok, Manila, Mexico City, and New Delhi are often entombed in a pall of pollution from trucks and cars and from uncontrolled industrial emissions. In 1995, for example, the average ozone concentration in Mexico City was about 0.15 parts per million, 10 times the natural atmospheric concentration and twice the maximum permitted in Japan or the US (96, 157). Ozone is a powerful secondary pollutant formed when oxides of nitrogen and unburned volatile organic hydrocarbons, mostly from vehicle exhausts, combine with oxygen under the action of sunlight. Ozone is a main component of smog.

Another powerful secondary pollutant is acid rain, formed when sulfur dioxide and oxides of nitrogen combine with water vapor and oxygen in the presence of sunlight to form a diluted "soup" of sulfuric and nitric acids. They can fall as both wet (acid rain) or dry deposition. Other harmful pollutants include sulfur dioxide, suspended particulate matter (soot, ash, and smoke from fires), carbon monoxide from vehicle exhausts, and lead, mainly from the exhaust of vehicles that burn leaded gasoline (262).

Air pollution is not only a health hazard but also reduces food production and timber harvests, because high levels of pollution impair photosynthesis. In Germany, for example, about US$4.7 billion a year in agricultural production is lost to high levels of sulfur, nitrogen oxides, and ozone (227).

Water Pollution

Globally, 2.3 billion people suffer from diseases linked to water. Providing safe drinking water and adequate sanitation would have major health benefits. Some benefits include an estimated 2.1 million fewer deaths from diarrheal diseases, 150 million fewer cases of schistosomiasis, and 75 million fewer cases of trachoma (63, 261).

Water-borne diseases, also known as "dirty water" diseases, result from using water contaminated by human, animal, or chemical wastes. These diseases cause an estimated 12 million deaths a year, 5 million of them from diarrheal diseases. Most of the victims are children in developing countries (46, 222, 227).

In many places both surface and ground waters are fouled with industrial, agricultural, and municipal wastes. According to the World Commission on Water for the 21st Century, more than half of the world's major rivers are so depleted and polluted that they endanger human health and poison surrounding ecosystems (117). In many large cities in the developing world the drinking water supply is contaminated. Only half of Southeast Asia's 550 million people have access to safe drinking water (237).

Pollution from Heavy Metals

Illnesses traced to heavy metals date back to ancient Rome, where lead pots, pipes, and smelters were held responsible for loss of intelligence among children and for brain damage and abnormal behavior among adults (181). Heavy metals released into the environment today come from uncontrolled emissions by metal smelters and other industrial activities, unsafe disposal of industrial wastes, and lead in water pipes, paint, and gasoline.

The heavy metals most dangerous to health include lead, mercury, cadmium, arsenic, copper, zinc, and chromium. Such metals are found naturally in the soil in trace amounts, which pose few problems. When concentrated in particular areas, however, they present a serious danger. Arsenic and cadmium, for instance, can cause cancer. Mercury can cause mutations and genetic damage, while copper, lead, and mercury can cause brain and bone damage (262).

Lead additives in gasoline cause widespread health problems in some countries. In Thailand, for example, a 1990 study found that some 70,000 children in Bangkok risked losing four or more points of IQ (Intelligence Quotient, based on standardized tests) because they were heavily exposed to lead emissions from motor vehicles. In Latin America some 15 million children under the age of two are at risk of ill health from lead pollution (227).

In the US leaded gasoline began to be phased out after the passage of the Clean Air Act in 1970. It was not until the mid-1980s, however, that the European Community followed suit. Elsewhere, leaded gasoline continues to be used extensively (181, 227).

Persistent Organic Pollutants

Human exposure to persistent organic pollutants (POPs) occurs in several ways—in foods, mostly as pesticide residues; occupationally, as among farm workers who spray pesticides on crops; and through accidents, including leaks in indoor storage areas (6, 261). POPs are organic compounds that have long lives in the environment and undergo physical, chemical, and biological changes over time.

What makes POPs especially dangerous is that they tend to accumulate in the fatty tissues of animals and humans. They climb the food chain, increasing in concentration as one organism eats a lower one, lodging eventually in human beings and such top predators as polar bears and wolves. Once in the human body, they mimic the function of steroid compounds, such as hormones, leading to the disruption of the endocrine system. Such disruption can damage reproductive health, causing sterility, birth defects, cancers, and spontaneous abortions, among other adverse effects (147).

POPs also can travel great distances in air or water. Greenlanders, for example, live thousands of miles from any known source of the pesticide hexachlorobenzene (HCB), but they have 70 times as much of this pollutant in their

Sara A. Holtz, Peace Corps

In rural Togo a village woman collects water for family use from a shallow well. Globally, some 2.3 billion people suffer from water-borne diseases. Providing safe drinking water and adequate sanitation would have important health benefits.

bodies as people from temperate areas of Canada (130, 134). The highest concentrations of one of the most potent POPs—polychlorinated biphenyls (PCBs)—have been found in Inuit people in the remote Arctic. Their levels are several hundred times higher than those reported anywhere else (134). This carcinogenic chemical has been found in elevated concentrations in the blubber of whales and seals, which are important food sources for the Inuit people.

In Denmark epidemiologists have noted a threefold increase in testicular cancer over the past 50 years, an increase that they attribute to proliferation of toxic chemicals, such as POPs, in the food chain (261). Some think that high levels of DDT may predispose women to breast cancer (28).

Global negotiations are now underway to ban or greatly limit use of 12 dangerous compounds, mostly pesticides. The first international meeting to discuss a global treaty to limit POPs took place in Montreal in July 1998. Currently, a framework treaty is being negotiated under the auspices of the United Nations Environment Program (UNEP). It is expected to be ready for signature by the end of 2000 (6). By signing the treaty, nations will commit themselves to concrete steps to phase out production and use of these chemicals by a specified date.

R. Faidutti/FAO

In Eritrea a farmer sprays pesticide on his fields. Increasingly, toxic chemicals are entering the food chain, with serious effects on human health. Global negotiations are underway to limit use of 12 dangerous chemical compounds, mostly pesticides.

Environmental Distress Syndrome

In recent years scientists have become increasingly concerned about the long-term effects of deteriorating environmental conditions on the health not only of humans but also of nature itself. "We are no longer talking only of an increased exposure to specific extraneous hazards as a cause of

Table 2. Types of Possible Adverse Effects Upon Health Due to Global Environmental Change

		Direct Health Effects		Indirect Health Effects	
Environmental Change	*Manifestation*	*Early*	*Late*	*Early*	*Late*
Enhanced greenhouse effect	*Global warming and climate change*	Heatwave-related illness and deaths Natural disasters: cyclones, floods, landslides, fires		Altered distribution of vector-borne infectious diseases. Food shortages due to altered agricultural productivity.	Reduced viability of edible fish in warmed oceans
Stratospheric ozone depletion	*Increased ultraviolet radiation at earth's surface*	Sunburn, photo keratoconjunctivitis. Suppression of immune system—increased risk of infection, cancer.	Skin cancer. Ocular effects: cataracts pterygium		Impaired growth of food crops and of marine microorganisms
Acid emissions (from combustion of sulphurous fossil fuels)	*Acid rain (and other precipitation)*	Possible effects on respiratory system		Killing of aquatic life—reduced food. Impaired crop growth.	Impairment of forest growth; reduced ecosystem productivity
Land degradation: over-intensive agriculture and excessive grazing	*Erosion, sterility, nutrient loss, salinity; desertification*	Decline in agricultural productivity	Rural depression—migration to fringes of cities (shanty towns)	Exposure to higher levels of pesticides and fertilizers; may lead to toxic algal blooms in waterways	Consequences of silting up of dams and rivers
Depletion of plants and animals; loss of biodiversity	*Destruction of habitat* *Loss of genetic diversity; weakening of ecosystems*	Deforestation: disruption of local culture and health	Shortages of edible species	Loss of medicinal chemicals and other health-supporting materials	Deforestation—greenhouse enhancement. Greater vulnerability of plants and livestock. Decline in vitality of ecosystems.

Note: The designations "early" and "late" are only to indicate the relative time of occurrence Source: Adapted from McMichael, 1993 (151) *Population Reports*

bad health. We are also recognizing the depletion or disruption of natural biophysical processes that are the basic source of sustained good health," points out epidemiologist Tony McMichael of the London School of Hygiene and Tropical Medicine (152).

At increasing risk, according to McMichael, are the ecosystems that determine food productivity and such global systems as the hydrological cycle—in which water evaporates from bodies of water and returns to them after falling as precipitation—and the stratospheric "ozone shield" that protects against excessive solar ultraviolet radiation. Such environmental changes would have a wide variety of negative effects on human health (see Table 2).

Some ecologists use the term "environmental distress syndrome" to identify deteriorating environmental conditions and resulting threats to health. Paul Epstein of Harvard Medical School lists four symptoms of this syndrome (61):

- Re-emerging infectious diseases, including typhoid, cholera, and pneumonia, and the emergence of new diseases, such as drug-resistant tuberculosis and human reproductive disorders linked to industrial chemicals.
- Loss of biodiversity and the consequent loss of potential sources of new medicinal drugs and food crops.
- The decline in pollinators, such as bees, birds, bats, butterflies, and beetles, which are indispensable to the reproduction of flowering plants.
- Proliferation of harmful algae along the world's coastlines, leading to more deadly outbreaks of diseases such as ciguatera poisoning and paralytic shellfish poisoning.

Such symptoms raise a disturbing question: At what point might the depletion of the world's ecological and biophysical capital undermine global public health? For instance, WHO has reported that a recent epidemic of meningitis in sub-Saharan Africa could be linked to an expansion of degraded agricultural and grazing land—a result of changes in land-use patterns (less vegetative cover) and less rainfall due to regional climate change triggered by human activities (152).

One study links a marked increase in diarrheal diseases among Peruvian children to the frequent and severe El Niño weather patterns, which are characterized by heavy rainfall and result from unusual warming of the equatorial Pacific Ocean. El Niño has been linked to outbreaks of dengue fever, malaria, and cholera. Its patterns have been made worse by global climate change (33) (see box, p. 16).

The organisms that transmit such diseases as malaria, dengue fever, and schistosomiasis are sensitive to temperature, humidity, rainfall patterns, and wind. Increases in temperature tend to accelerate the life cycles and decrease the incubation periods of the parasite or virus. These changes extend the time during which the diseases are transmitted and encourage their spread to new areas (62 , 131, 150).

Global climate change also has indirect effects upon the transmission of diseases (150). For example, global warming would increase the need for irrigation. In hot climates the prevalence of schistosomiasis already has increased due largely to the expansion of irrigation systems and dams. These systems support more water snails, an intermediate host of the schistosomiasis worm, and bring more people into closer contact with worms (131).

Marilyn Pfaltz

Around the world millions of children and adults do not get enough to eat. In 64 of 105 developing countries studied by the UN, food production has lagged behind population growth. About 2 billion people lack food security.

Feeding a Future World

Will there be enough food to go around? Rapid population growth, environmental degradation, and inadequate international food distribution raise this question. About 2 billion people lack food security—defined by the UN Food and Agriculture Organization (FAO) as a "state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life" (75).

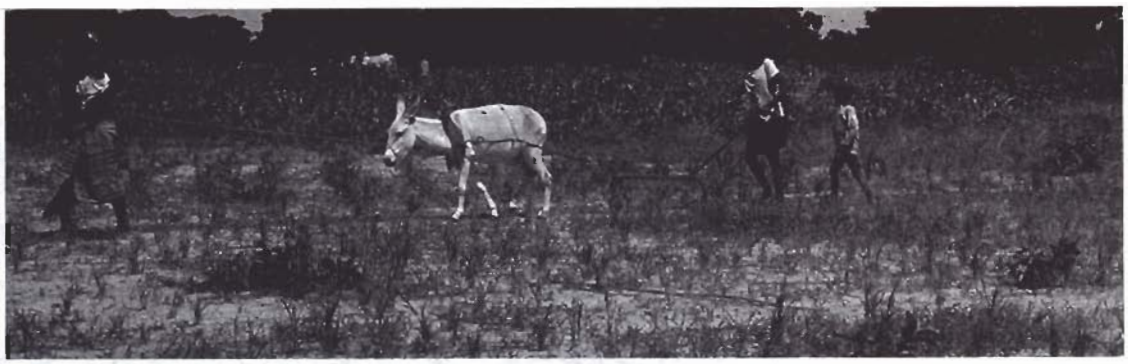
In many countries over the past two decades growth in the food supply has lagged behind population growth (75). Worldwide, the grain harvest increased about 1% annually between 1990 and 1997, a rate of growth substantially slower than the average population growth rate in the developing world, at 1.6% (21, 23, 53, 113).

In 64 of 105 developing countries studied by FAO between 1985 and 1995, food production lagged behind population growth (74). Among regions, Africa fared the worst during this period. Food production per person fell in 31 of 46 African countries (74, 95).

Moreover, water shortages are becoming constraints on development in general and on food production in particular (186, 201). While population tripled in the last century, water withdrawals grew sixfold (120, 233) (see p. 13).

Countries fall into three groups: (1) those that have the agricultural capacity to be self-sufficient in food production; (2) those that are not self-sufficient in food production but have enough other resources to import adequate supplies of food; and (3) those that are not self-sufficient in food production and do not have the financial resources needed to fill the gap with imports.

In the first group, the agriculturally self-sufficient countries, are some European countries plus Australia, Canada, and the United States. These countries have sufficient cropland to



Susanne Rivelas, Lutheran World Relief

In Burkina Faso, as elsewhere in Africa, villagers often have little choice but to farm marginal land. In many developing countries pressures on arable land, freshwater supplies, and other resources have been rising because of population growth.

Table 3. The 82 Low-Income Food-Deficit Countries, 1999

Region & Country	Population 2000 (Millions)	Population Growth Rate (%)	Projected Population 2050 (Millions)
AFRICA, SUB-SAHARAN			
Angola	12.9	3.0	36.9
Benin	6.4	2.8	18.1
Burkina Faso	11.9	2.9	34.3
Burundi	6.1	2.5	16.1
Cameroon	15.4	2.6	34.7
Cape Verde	0.4	2.8	0.4
Central African Rep.	3.5	2.0	6.4
Chad	8.0	3.3	31.5
Comoros	0.6	2.8	1.8
Congo, Dem. Rep.	52.	3.2	181.9
Congo, Rep.	2.8	2.4	6.9
Côte d'Ivoire	16.0	2.2	30.5
Djibouti	0.6	2.3	1.3
Equatorial Guinea	0.5	2.5	1.1
Eritrea	4.1	3.0	13.7
Ethiopia	64.1	2.4	187.9
Gambia	1.3	2.4	2.8
Ghana	19.5	2.4	32.0
Guinea	7.5	2.4	18.1
Guinea-Bissau	1.2	2.2	2.7
Kenya	30.3	2.1	38.7
Lesotho	2.1	2.1	2.8
Liberia	3.2	3.2	10.0
Madagascar	14.9	2.9	46.9
Malawi	10.4	1.9	14.7
Mali	11.2	3.1	31.4
Mauritania	2.7	2.7	6.6
Mozambique	19.1	2.2	22.9
Niger	10.1	3.0	28.5
Nigeria	123.3	2.8	303.6
Rwanda	7.2	2.3	8.9
Sao Tome & Principe	0.2	3.4	0.5
Senegal	9.5	2.8	23.1
Sierra Leone	5.2	2.6	15.7
Somalia	7.3	2.9	25.5
Swaziland	1.0	1.9	3.1
Tanzania	35.3	2.9	88.3
Togo	5.0	3.1	9.7
Zambia	9.6	2.0	20.3
ASIA & PACIFIC			
Afghanistan	26.7	2.5	76.2
Bangladesh	128.1	1.8	210.8
Bhutan	0.9	3.1	2.0
Cambodia	12.1	2.6	29.0

Region & Country	Population 2000 (Millions)	Population Growth Rate (%)	Projected Population 2050 (Millions)
ASIA & PACIFIC (cont.)			
China	1,264.5	0.9	1,369.0
India	1,002.1	1.8	1,628.0
Indonesia	212.2	1.6	311.9
Laos	5.2	2.6	11.8
Maldives	0.3	3.0	0.7
Mongolia	2.5	1.4	4.1
Nepal	23.9	2.5	49.3
North Korea	47.2	0.9	51.1
Pakistan	150.6	2.8	285.0
Philippines	80.3	2.3	139.6
Sri Lanka	19.2	1.2	25.9
LATIN AMERICA & CARIBBEAN			
Bolivia	8.3	2.0	15.5
Cuba	11.1	0.7	10.6
Ecuador	12.6	2.1	21.2
Guatemala	12.7	2.9	32.2
Haiti	6.4	1.7	11.9
Honduras	6.1	2.8	11.0
Nicaragua	5.1	3.0	11.6
NEAR EAST & NORTH AFRICA			
Egypt	68.3	2.0	117.1
Morocco	28.8	1.7	46.1
Sudan	29.5	2.2	59.2
Syria Arab Rep.	16.5	2.8	35.3
Yemen	17.0	2.8	69.3
EAST EUROPE & CENTRAL ASIAN REPUBLICS			
Albania	3.4	1.3	5.2
Armenia	3.8	0.4	3.8
Azerbaijan	7.7	0.9	11.5
Bosnia & Herzegovina	3.8	0.5	3.9
Georgia	5.5	0.2	4.2
Kyrgyzstan	4.9	1.5	6.1
Macedonia, FYR	2.0	0.6	2.1
Tajikistan	6.4	1.6	9.5
Turkmenistan	5.2	1.5	7.5
Uzbekistan	24.8	1.7	33.8
OCEANIA			
Kiribati	0.1	2.5	0.2
Papua New Guinea	4.8	2.4	9.5
Solomon Islands	0.4	3.1	1.1
Tuvalu	0.01	1.4	0.02
Vanuatu	0.2	2.8	0.3
Western Samoa	0.2	2.5	0.2
TOTALS	3,813.9	2.3	6,094.6

Source for list of countries: Food and Agriculture Organization of the United Nations (FAO), 1999 (78).
Source for population data: Population Reference Bureau, 2000 (182)

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meet most of their own food needs now and probably for many decades to come. In fact, many of these countries produce substantial surpluses of food, which they export (73, 75). They probably could produce enough to meet the food needs of all food-deficit countries, if those countries could afford to buy the food. Countries in the second group, food importers, include Japan, Singapore, some European countries, and the oil-producing states of the Arabian Gulf.

The third group consists of the "low-income food-deficit countries," to use the term coined by FAO (75). The low-income food-deficit countries comprise most of the developing world, including nearly all of sub-Saharan Africa (75, 78) (see Table 3).

Today, about 3.8 billion people—nearly two-thirds of the world's population—live in low-income food-deficit countries. In these countries millions know hunger, malnutrition, and even starvation when harvests fail, unless other countries provide emergency food aid in time. Worldwide, about 825 million people are chronically malnourished, according to a recent estimate by FAO (78, 278) (see Figure 1).

Many low-income food-deficit countries have among the world's highest population growth rates. By 2050 about 6 billion people will live in countries that have food deficits today (see Table 3).

Environmental Problems of Food-Deficit Countries

In many low-income food-deficit countries the situation is worsening. Food production capacities are deteriorating (75). These countries face a number of serious constraints to achieving food security:

Limited arable land. Most fertile land already is under cultivation. Most uncultivated land is marginal, with poor soils and either too little rainfall or too much. Without massive technological improvements or substantial investments from external sources, increases in food production in low-income food-deficit countries will soon have to come from existing agricultural land—thus putting ever more pressure on its productive capacity (49, 73).

Shrinking family farms. In most developing countries, family farms are divided into smaller and smaller parcels for each new, larger generation of heirs. Rapid population growth has shrunk the average family farm by half over the past four decades. In 57 developing countries surveyed by FAO in the early 1990s, over half of all farms were less than one hectare in size, not enough to feed the average rural family with four to six children. In India three-fifths of all farms are less than one hectare in size (73, 192). Worldwide, an estimated 420 million people live in countries that have less than .07 hectares of cultivated land per person (59).

Land degradation. Population pressures on arable land contribute to the land's degradation, as more and more marginal land is brought into cultivation to feed more and more people (23, 49). Land degradation claims 5 million to 7 million hectares of farmland each year (73). When soils are overworked, wind and water erode them faster. Soils also can become poisoned from improper irrigation techniques and from improper use of agricultural chemicals. Moreover, in most developing countries vast amounts of agricultural land are being lost as cities expand (see box, p. 12).

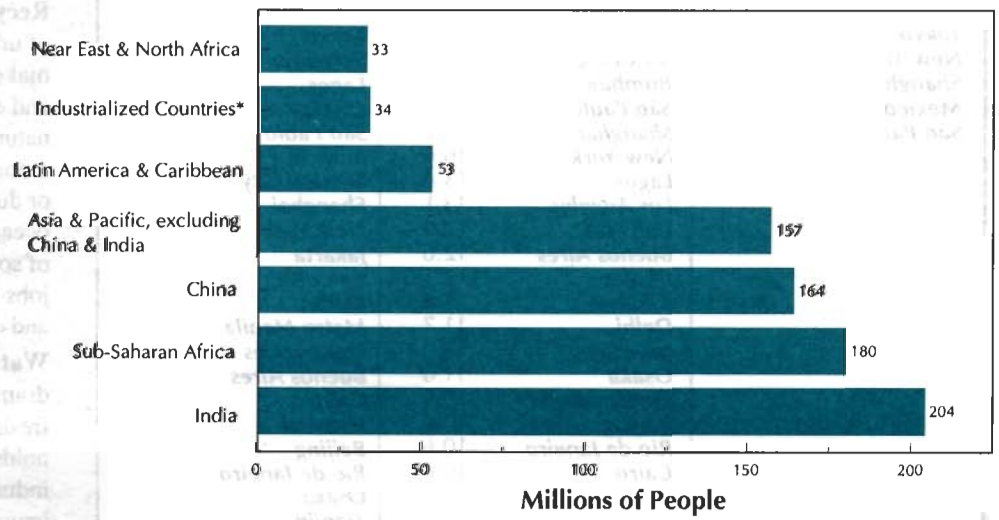
Nearly 2 billion hectares of crop and grazing land are suffering from moderate to severe soil degradation—an area about the size of Canada and the US combined (14, 52, 73). In some places fertile topsoil is being depleted 300 times faster than nature can replenish it (126). In Kazakhstan, for instance, nearly half of the cropland will be lost by 2025, according to the country's Institute of Soil Management (23).

Gene Thiemann, Lutheran World Relief

In Bangladesh family farms are being divided into ever smaller parcels for each new generation of heirs. In developing countries as a whole, the average family farm is half the size of 40 years ago.

Figure 1. Hunger Around the World

Number of Undernourished People, by Region, 1995–1997



Source: Food and Agriculture Organization of the United Nations (FAO), 1999 (78)
*Includes countries in transition.

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Cities at the Forefront

The rapid growth of cities in the developing world puts them in the forefront of the struggle for improved living standards and protection of the environment. Since 1950 the urban population has more than tripled, from just over 750 million to about 3 billion (171). By 2030 some 5 billion people will live in cities (239, 243). In the developing world the urban population is projected to double from 1.9 billion in 2000 to be just under 4 billion by 2030 (165, 239).

Worldwide, about three-fourths of all current population growth is urban (222, 239). Cities are gaining an estimated 55 million people per year—over 1 million new residents every week from in-migration and natural population increase within cities. In developing countries many cities are growing two or three times faster than population growth for the country as a whole (58, 84). As cities grow ever larger, their impact on the environment grows exponentially (249).

The Rise of Megacities

The UN coined the term megacities in the 1970s to describe cities with 10 million or more residents. As recently as 1975 there were only five megacities worldwide. Currently, there are 19 megacities, of which 15 are in developing countries. By 2015 the number of megacities will grow to 23 (239) (see Table 4). "Megacities have captured public interest because cities this large are unprecedented in history, and because of the popular perception that human well-being will decline in such dense concentrations of people," writes demographer Martin Brockerhoff (273).

Millions of people move from the countryside to the city to seek a better life, but they often find that their lives become more difficult. In many cities 25% to 30% of the urban population live in poor shanty towns or squatter settlements, or they live on the streets (85, 222). Of Rio de Janeiro's 10.6 million residents, for example, 4 million live in squatter settlements and shanty towns, some perched precariously on steep hillsides (215). Nevertheless, cities in developing countries continue to attract more and more people.

Cities occupy only 2% of the world's land surface, but city populations have a disproportionate impact on the environment. For example, London requires roughly 60 times its land area to supply its 9 million residents with food and forest products (171). Because commerce and trade have spread dramatically in recent years, city residents consume resources not just from surrounding areas but, increasingly, from around the world (171, 191). Urban areas also export their wastes and pollutants, affecting environmental and health conditions far from the cities themselves.

What Can Be Done?

In the long run, slowing population growth would help ease the pressure on cities, buying time to make improvements in technology. Municipalities also can take a number of steps now—building better transportation systems, promoting recycling, and encouraging water conservation.

Public transportation. One of the best investments that cities can make—both environmental and economic—is an efficient mass transportation system. In many cities people waste great amounts of time and fuel going nowhere because traffic congestion is severe. In many urban areas vehicular exhausts account for 50% to 70% of polluting emissions. Curbing the number of motor vehicles by offering transportation alternatives would save energy and reduce pollution. Some cities—for example, Amsterdam and Copenhagen—have helped ease the transportation crisis by creating special traffic lanes for bicycles and by urging bicycle use.

Recycling. Recycling mountains of urban waste into new resources makes sense both environmentally and economically. Recycling saves natural resources and reduces the amount of trash deposited in landfills or dumped into rivers, lakes, and the ocean. Also, for every million tons of solid waste, about 1,600 recycling jobs could be created in developed and developing countries alike (271).

Water conservation. Urbanization dramatically increases per capita freshwater use, as millions of households gain access to piped water, as industry increases, and as large-scale irrigated agriculture replaces subsistence farming. Cities everywhere need to adopt water conservation measures.

Table 4. Megacities of the World

Cities with 10 Million or More Inhabitants, 1975, 2000, and 2015 (Population in Millions)

City—1975	Population	City—2000	Population	City—2015	Population
Tokyo	19.8	*Tokyo*	26.4	*Tokyo*	26.4
New York	15.9	*Mexico City*	18.1	*Bombay*	26.1
Shanghai	11.4	*Bombay*	18.1	*Lagos*	23.2
Mexico City	11.2	*São Paulo*	17.8	*Dhaka*	21.1
São Paulo	10.0	*Shanghai*	17.0	*São Paulo*	20.4
		New York	16.6	*Karachi*	19.2
		Lagos	13.4	*Mexico City*	19.2
		Los Angeles	13.1	*Shanghai*	19.1
		Calcutta	12.9	*New York*	17.4
		Buenos Aires	12.6	*Jakarta*	17.3
		Dhaka	12.3	*Calcutta*	17.3
		Karachi	11.8	*Delhi*	16.8
		Delhi	11.7	*Metro Manila*	14.8
		Jakarta	11.0	*Los Angeles*	14.1
		Osaka	11.0	*Buenos Aires*	14.1
		Metro Manila	10.9	*Cairo*	13.8
		Beijing	10.8	*Istanbul*	12.5
		Rio de Janeiro	10.6	*Beijing*	12.3
		Cairo	10.6	*Rio de Janeiro*	11.9
				Osaka	11.0
				Tianjin	10.7
				Hyderabad	10.5
				Bangkok	10.1

Source:
UN Population Division, March 2000 (239)

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Irrigation problems. Badly planned and poorly built irrigation systems have reduced yields on one-half of all irrigated land, according to a 1995 estimate by FAO (73). Irrigation is key to agricultural production. Although only 17% of all cropland is under irrigation, irrigated croplands produce one-third of the world's food supply (178).

Roughly 70% of all water withdrawn for human use goes to irrigate crops. Yet less than half of all water withdrawn for irrigation reaches the crops. Most soaks into unlined canals, leaks out of pipes, or evaporates on its way to the fields (186). Although some of the water "lost" in inefficient irrigation systems returns to streams or aquifers, where it can be tapped again, water quality invariably is degraded by pesticides, fertilizers, and salts that run off the land (104).

In Egypt workers dredge an irrigation canal. About 70% of all water withdrawn for human use goes to irrigate crops. Yet less than half of all water withdrawn for irrigation reaches the crops.

Salt buildup in soil has severely damaged 30 million hectares of the world's 255 million hectares of irrigated land, FAO estimates. A combination of salinization and waterlogging affects another 80 million hectares (73, 186). The world's irrigated croplands may actually be shrinking at a time when they should be expanding to meet demand (23).

What Can Be Done?

Achieving food security means addressing several related issues: slowing population growth, increasing food production, and safeguarding the environment. Since, of course, not every country can be self-sufficient in food production, international trade will become increasingly important in the future to achieve food security worldwide. In low-income food-deficit countries slower population growth would allow time to achieve food security.

To provide food security for all of the 8 billion people projected by 2025, the world would have to double food production over current levels (73, 75). Achieving this goal would require a second "Green Revolution" in agriculture, like the one in the 1960s that boosted food production in the face of population increases.

Recent years have brought some promising developments. These include a new strain of super rice capable of boosting yields by 25% (160, 175), improved varieties of corn that could increase yields perhaps by 40% and that could be grown on marginal land (93), and a new blight-resistant potato (174).

To achieve food security, the food-deficit countries must reverse the current course of land degradation and begin to manage soil and water resources on a sustainable basis. There are many ways to protect agricultural land. In many areas, for example, irrigated land could be managed better by using hand pumps and traditional water harvesting techniques rather than relying on large-scale automated sprinkler systems (5) (See **Population Reports**, *Winning the Food Race*, Series M, No. 13, December 1997). Specific solutions will vary from one area to another. Virtually everywhere, however, protecting the environment will help produce more food to feed more people (73, 178, 186).

Freshwater: Lifeblood of the Planet

Demand for freshwater is rising rapidly as population grows and becomes more urban, and as water use per capita increases. Some areas already face shortages, and more will face them in the future unless steps are taken to manage water resources better.

The supply of freshwater on earth is finite. Thus, as population grows, there is less water per capita. In 1989 there were about 9,000 cubic meters of freshwater per person available for human use (37, 135). By 2000, because of population growth, that amount dropped to about 7,800 cubic meters per person (88). If the world's population grows to over 8 billion in 2025 as expected, the amount of water per capita will be just 5,100 cubic meters (45).

Even this amount of freshwater per capita would be enough to meet human needs if it were evenly distributed. But available freshwater supplies are not distributed evenly around the globe, throughout the seasons, or from year to year. Two-thirds of the world's population—around 4 billion people—live in areas receiving only one-quarter of the world's annual rainfall (87).

Throughout much of the world the renewable supply of freshwater—the amount available year after year on a sustainable basis—comes in the form of seasonal rains that run off too quickly for efficient use (185). India, for example, gets 90% of its annual rainfall during the summer monsoon season, which lasts from June to September. For the other eight months the country gets barely a drop (37).

Lauren Goodsmith

In Morocco a girl loads water barrels onto a donkey. By 2025, about 700 million people in Africa will live in water-short countries. Worldwide, 48 countries, with about 3 billion people, are projected to face water shortages.

Water Shortages

Already, population growth and rising use per capita are creating water shortages in many countries. A country is said to experience water stress when annual water supplies drop below 1,700 cubic meters per person. When supplies drop below 1,000 cubic meters per person per year, the country faces water scarcity for all or part of the year. Swedish hydrologist Malin Falkenmark developed these concepts of stress and scarcity to gauge current and future water needs against available supplies (64, 66, 82).

In 1995 Population Action International (PAI) adapted Falkenmark's concepts to calculate water stress and scarcity in countries around the world. PAI updated this estimate in 1997, based on population projections for 2025 and 2050. The results are startling: In 1995, 31 countries—home to nearly half a billion people—regularly faced either water stress or water scarcity. In 2025, 48 countries, with about 3 billion people, are projected to face water shortages (60, 82). The 20 countries of the Near East and North Africa face the worst prospects. In fact, the Near East "ran out of water" as long ago as 1972—in the sense that since then the region has withdrawn more water from its rivers and aquifers than is being replenished by nature (154). Currently, for example, Jordan and Yemen withdraw 30% more water from groundwater supplies every year than is replenished; Israel's annual water use exceeds the renewable supply by 15% (183, 185).

Africa also faces serious water problems. Already, over 200 million Africans live in water-stressed or water-scarce countries. By 2025 the number will rise to about 700 million, of whom over half will live in countries that face severe shortages for most of the year (65, 67, 182).

If water stress and water scarcity were calculated for regions instead of countries, parts of many other countries would be considered at risk. For example, while periodic flooding afflicts the southern part of China, the northern part faces chronic water shortages (22, 82). China's freshwater supplies have been estimated to be capable of supporting 650 million people on a sustainable basis—only about half the country's current population (190).

Competing for water supplies. When water supplies become scarce, competition can become intense. In recent years withdrawals of freshwater have grown in all categories of demand—for irrigated agriculture, industrial use, and municipal (household) purposes (139, 222, 244). Freshwater demand for municipal use is expected to outpace the capacity of many cities to provide it (237). In Bangkok, Dhaka, Lagos, and other rapidly growing cities, water theft has become widespread (137, 173, 220).

Because more than 200 major river systems cross national borders, cooperation can help avoid international conflict. For example, in November 1999 Egypt, Ethiopia, and Sudan agreed in principle on a strategy for using the Nile River "for the common benefit of all the river basin states" (172). If implemented, the agreement—which covers all uses of the river for irrigation, hydropower, drainage, drought and flood control, and pollution prevention—would be a breakthrough in cooperative use of a vital natural resource.

Competing with nature. A substantial portion of the total freshwater supply is needed to sustain marshes, rivers, coastal wetlands, and the millions of species they shelter (68). As humanity withdraws more freshwater for direct use, less is available to maintain wetland ecosystems (12, 184, 187). Over 20% of the approximately 10,000 freshwater fish species in the world are either endangered or are already going extinct because their habitats are being threatened (18, 120) (see p. 21).

Wetland ecosystems are economically valuable. Robert Costanza of the University of Maryland estimates the global value of wetlands at close to US$5 trillion a year. This amount reflects the value of wetlands as flood regulators, waste treatment plants, wildlife habitats, fisheries production, and recreation (107).

The world's 6 billion people are already appropriating just over half of all the accessible freshwater contained in rivers, lakes, and underground aquifers. By 2025 humankind's share will be at least 70%. This conservative estimate reflects the impact of population growth alone. If per capita consumption of water resources continues to rise at its current rate, humankind could be using over 90% of all available freshwater within 25 years, leaving just 10% for the rest of the world's species (106, 187).

What Can Be Done?

Caught between growing demand for freshwater on one hand and limited and increasingly polluted supplies on the other, many countries face difficult choices. Finding solutions requires responses at local, national, and international levels—a "Blue Revolution" that focuses on integrated management of watersheds and shared water basins (104) (see **Population Reports,** *Solutions for a Water-Short World,* Series M, No. 14, September 1998).

Community-led initiatives to manage water resources better can help urban dwellers gain access to safe, piped water supplies, thus improving sanitation and public health (46, 119). Governments can develop national water management policies that not only improve supply but also manage demand better with appropriate pricing—for example, ending subsidies that in effect encourage overuse (221).

Oceans in Decline

Over half of the world's coastlines face environmental pressures from population growth and economic development. A rising tide of pollution threatens the seas. Coastal and ocean fisheries—containing most of the world's wild food harvest—are fast being depleted.

Coastlines

About half of all coastal areas face moderate to severe environmental stress from population growth and development pressures, according to a 1995 review by the World Resources Institute (WRI) (26, 274). The coastlines of most developed countries—particularly Japan, Australia, the US, Europe, and the European part of Russia—suffer degradation. Developing countries fare little better.

About half the world's population occupies a coastal strip 200 kilometers wide—only 10% of the world's land surface. Two-thirds of the world's people live within 400 kilometers (240 miles) of a seacoast. Given such population density, human activities are eroding close to 70% of the world's beaches at greater than natural rates (4). Erosion is a natural process, but it can be made worse by coastal development such as construction, urban expansion, sand dredging, and harvesting coral reefs for building material (102, 230, 255).

The world's coastal wetlands are disappearing. Around the world, about 182,000 square kilometers of mangrove wetlands provide a habitat for over 2,000 species of fish, shellfish, invertebrates, and plants. In the past century over half the world's original mangrove area has been destroyed or degraded, been converted to agricultural land or fish ponds, or fallen victim to urban and industrial development (102).

Seagrass beds also are vanishing. These underwater ocean meadows support a wide variety of commercially valuable species of fish and shellfish. Although no overall estimates of damage are available, these ecosystems appear to be shrinking near virtually all inhabited coastal areas (79).

Coral Reefs

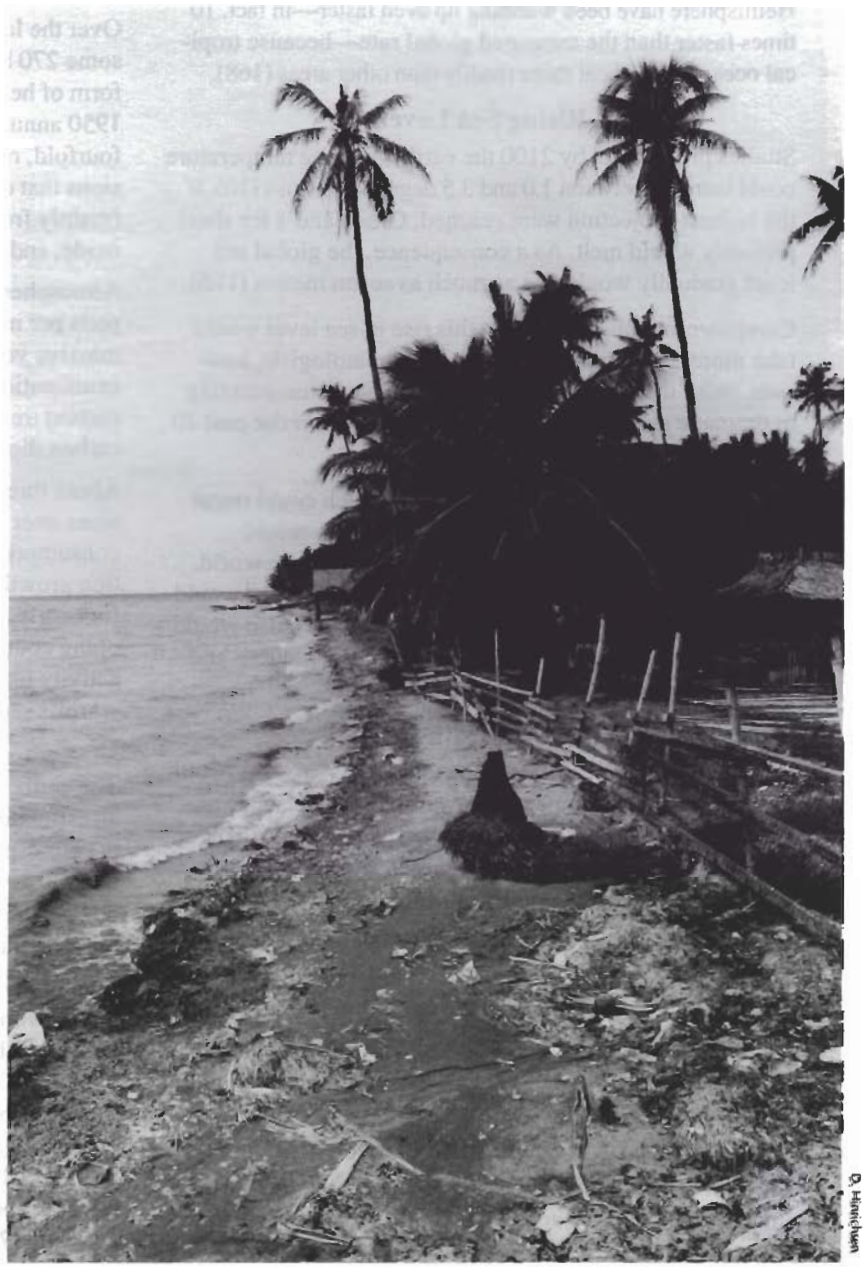
Development activities are destroying most of the world's coral reefs. Of the world's 600,000 square kilometers of reefs in tropical and semi-tropical seas, scientists estimate that 70% could be lost within 40 years (102, 251). Coral reefs are being buried by sediment washed off the land, poisoned by industrial and agricultural chemicals, reduced to rubble by fishermen using dynamite, damaged by boat anchors and careless divers, excavated for use as building material, and bleached white by warming ocean temperatures.

Coral reefs provide humankind with many benefits. Reefs support upwards of 1 million species. They provide feeding, breeding, and nursery areas for fish and shellfish and offer humanity a pharmacopoeia of potential medicines. They buffer waves and protect shorelines from storms. Coral reefs have been valued at US$47,000 per square foot of shoreline for their protection functions alone (40).

In 1997 a global effort to assess the status of coral resources was carried out by Reef Check, organized by Hong Kong University. The study engaged professional and recreational divers to chart the health of 300 coral reefs in 30 countries. Less than one-third of all reefs studied had healthy, living coral cover (101). According to a 1998 assessment by WRI, the world's most degraded reefs are in Southeast Asia and the Caribbean (24).

Few people recognize how important reefs are. In Indonesia, for example, less than half of respondents surveyed in 2000 viewed coral reefs as a marine resource. In urban areas less

(Text continues on page 18.)



Coasts along the Philippine island of Negros suffer from erosion caused by rising seas and poor land-use practices. Over half of the world's coastlines face environmental degradation from population growth and development.

Global Warming: Worrisome Signs

Scientists increasingly agree that the earth's atmosphere is becoming warmer. A long-term rise in the global climate could cause sea levels to rise around the world and bring a number of other adverse consequences (62). Reliance on fossil fuels as an energy source and the widespread destruction and burning of forests are chiefly responsible for the carbon emissions—the so-called greenhouse gases—that lie behind global warming (20, 69, 110, 140, 167, 213, 264).

One indication of global warming is that over the past 40 years the ocean surface (the top 1,000 feet) has warmed an average of half a degree Celsius (168, 209). The US National Oceanic and Atmospheric Administration (NOAA) has reported that tropical waters in the Northern Hemisphere have been warming up even faster—in fact, 10 times faster than the measured global rate—because tropical oceans retain heat more readily than other areas (168).

Rising Sea Levels

Studies project that by 2100 the earth's surface temperature could increase between 1.0 and 3.5 degrees Celsius (110). If the highest projection were reached, Greenland's ice sheet probably would melt. As a consequence, the global sea level gradually would rise as much as seven meters (176).

Computer models project that this rise in sea level would take more than a millennium. Some climatologists, however, think that sea levels could rise much faster, pointing to dramatic shrinkage of the Arctic ice cap over the past 30 years (138).

Even a rise of one meter in sea level—which could occur by 2080, according to the computer models—would inundate many low-lying coastal areas around the world. For instance, much of the Nile River Delta of Egypt would disappear. A one-meter rise in global sea levels also would inundate close to 20% of the coastline of Bangladesh and displace millions of people (111, 130).

Adverse Health Effects

Rising global temperatures also would carry adverse health consequences. As temperatures warmed and episodes of droughts and floods became more frequent, the incidence of water-borne diseases and a resurgence and spread of infectious diseases carried by mosquitoes and other disease vectors probably would increase (62).

Warmer global temperatures also would magnify the effects of human activities on the environment, including more pollution and habitat destruction. Climate change might even cause some ecosystems to exceed critical thresholds, leading to their irreversible decline (166).

Growing Scientific Consensus

In 1988, to help study and focus attention on the issues, the Intergovernmental Panel on Climate Change was created under the auspices of the World Meteorological Organization and the United Nations Environment Program. The panel has involved as many as 2,000 scientists from around the world. In 1996 a panel report concluded firmly that global climate change is a reality and not just a possibility (110).

After reviewing the evidence, the panel determined that:

- Evidence for the link between climate change and human activities is compelling. Already, increases in carbon dioxide and other climate-changing gases have upset the balance of the earth and its atmosphere.
- The earth's surface has become warmer; the number and severity of storms have increased; and the global sea level has risen by 10–25 cm over the past century.

Because the warming trend is a global problem, solutions must be global in scope, the panel concluded (110).

Why Is the Climate Changing?

Over the last 150 years burning of fossil fuels has released some 270 billion tons of carbon into the atmosphere in the form of heat-trapping carbon dioxide gases (210). Since 1950 annual worldwide carbon emissions have increased fourfold, reaching 6.3 billion tons in 1997 (69). Other emissions that contribute to climate change include methane (mainly from domestic livestock and agriculture), nitrous oxide, and chlorofluorocarbons (262).

Atmospheric concentrations of carbon dioxide reached 363 parts per million in 1998, the highest level since the time of massive volcanic activity over 160,000 years ago, based on examination of ice cores in Antarctica and in the Arctic. If current trends continue, atmospheric concentrations of carbon dioxide would double during this century (69).

About three-fourths of the huge increase in carbon emissions over the past half-century is due to increased energy consumption per capita; about one-quarter is due to population growth (21). Western industrialized countries account for nearly half of atmospheric carbon emissions, but developing countries are producing a growing share as industrial activity increases and populations grow. China is now the world's second largest carbon emitter, after the US (69, 71).

Vanishing Carbon Sinks

The earth's forests are carbon sinks that currently soak up an estimated one-third of the carbon dioxide released into the atmosphere (see p. 19). When forests burn, whether naturally or when people clear the land, they not only release more carbon into the atmosphere but also diminish the amount of carbon-absorbing forest cover remaining.

Some scientists are concerned that droughts caused by global warming will increase the number of forest fires, thus contributing further to carbon emissions in the atmosphere. For instance, the six months of extensive forest fires that occurred in Asia in 1997 and 1998 released more carbon into the atmosphere than Western Europe emits in a year (21). Burning trees for land clearance in the tropics releases about 1 billion tons of carbon into the atmosphere annually (71).

As more carbon fills the atmosphere, scientists worry that forests will become saturated and no longer play their role

as carbon sinks. Instead, they will start to release carbon themselves. As Will Steffen of Sweden's Royal Academy of Sciences has said, "Forests are temporary reservoirs that can buy valuable time to reduce industrial emissions, not permanent offsets to these emissions" (177).

Moreover, models developed by the Hadley Centre for Climate Prediction and Research in the UK project that, as the world warms, vast swaths of tropical forest—especially in the Amazon River Basin—could begin to dry out. If so, many tropical forests would die out. Their loss would mean even less ability to soak up carbon dioxide from the atmosphere, a trend that could accelerate global warming (176).

Agriculture at Risk

Higher carbon dioxide levels in the atmosphere would extend the agricultural growing season and promote forest growth in the short-run but would have potentially negative effects on crops and forests in the long run (110). Because the world's grain belts would become less productive, an additional 350 million people would go hungry by the middle of this century (279). Major droughts have been projected for sub-Saharan Africa as climatic patterns shift, reducing rainfall and drying out soils for longer periods (208).

In 1999 NOAA projected that by the middle of this century soils in agricultural regions of the central US, Central Asia, and the areas surrounding the Mediterranean Sea would likely experience substantial reductions in soil moisture during the summer growing season because evaporation rates would be higher. Such reductions in soil moisture would make these areas "particularly vulnerable," according to the study (167).

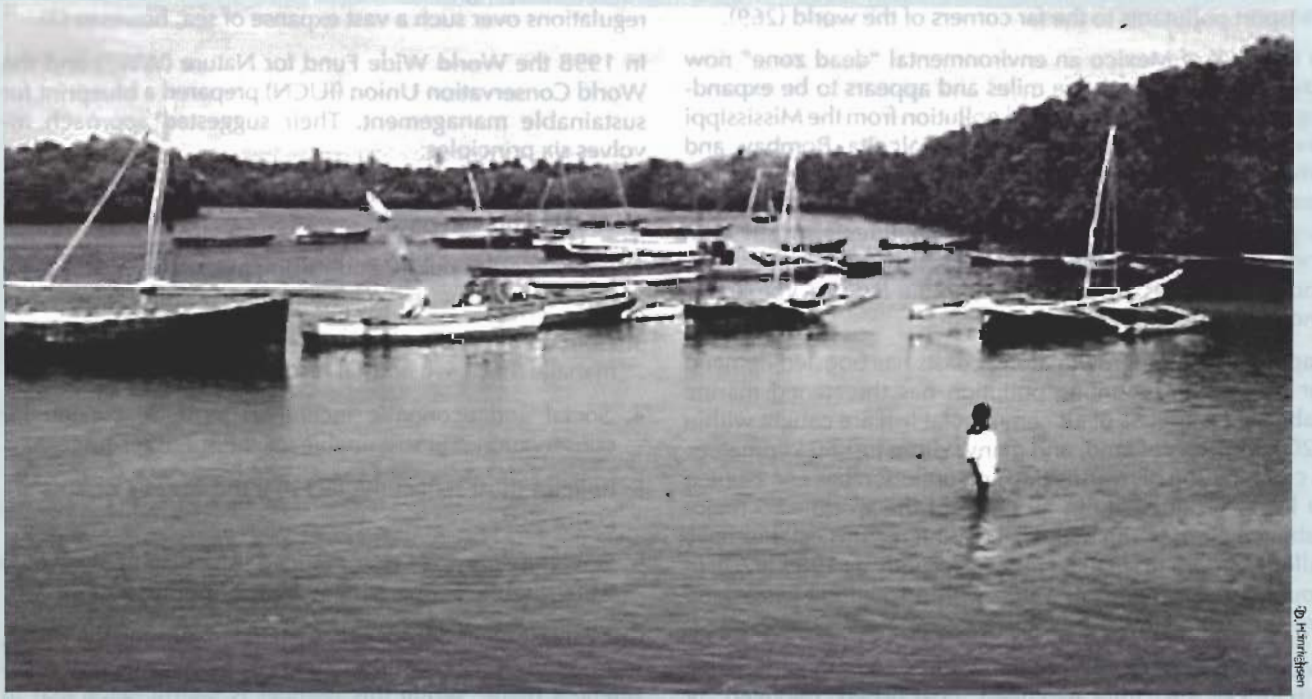
Others point out that, ironically, global warming could produce colder temperatures in northern Europe and Russia, reducing crop yields in these regions as well (51, 176, 207). This change would occur because the huge amounts of arctic freshwater from melting ice caps would make the water less dense. Such a change would interrupt the "conveyor belt" effect of the North Atlantic Drift, the ocean current that transports warm tropical water from the Gulf Stream to Scandinavia and northern Europe.

What Can Be Done?

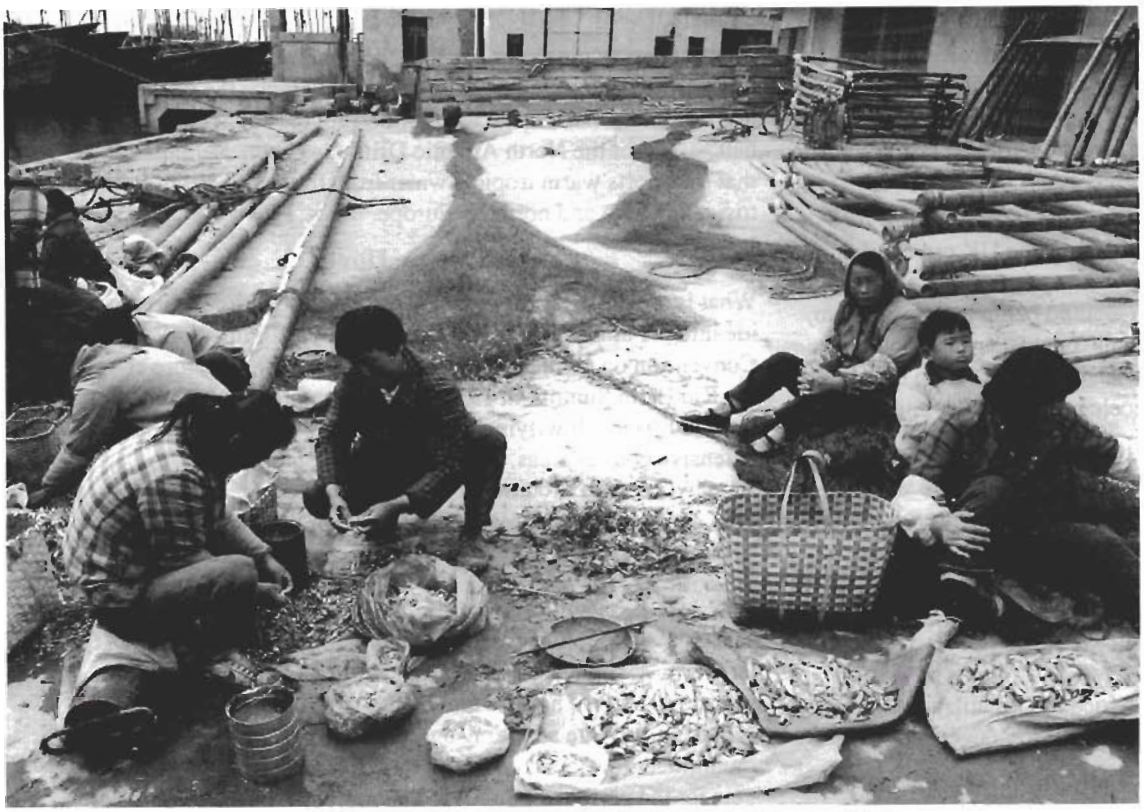
What is the prospect for reducing emissions of carbon dioxide into the atmosphere? The United Nations Framework Convention on Climate Change was opened for signature at the Rio Earth Summit in 1992. It was promptly signed and ratified by most low-lying island states and countries with extensive coastal areas. The Convention established a framework and a process for agreeing on specific actions later on; it asked signatory states to take preliminary action to reduce greenhouse gas emissions; and it encouraged scientific research on climate change.

The Convention, however, was not binding and did not set targets or deadlines (231). Consequently, in December 1997 representatives of nations around the world met in Kyoto, Japan to negotiate a binding agreement. The Kyoto Protocol committed developed countries to individual emissions targets for the period 2008–2012. The projected overall result would be a 5% reduction in emissions by those countries from 1990 levels by no later than 2012 (238). So far, however, only 14 countries—all from the developing world—have ratified the Protocol. It cannot take effect until at least 55 countries have ratified it (6, 238).

The next round of negotiations is scheduled for late 2000, to be held in The Hague, Netherlands. Can progress be made at this meeting? If too little is done, some experts worry that climate change trends could become irreversible (167, 199).



Many low-lying coastal areas, such as this mangrove forest in Kenya, would be submerged if sea levels rise as much as scientific models project based on trends in global warming. Even a rise of one meter would displace millions of people.



D. Hinrichsen

In a small fishing village near Shanghai, people sort through the day's sea catch. As in many places, China's coastal waters are becoming polluted as cities dump untreated wastes into the sea. Most of the world's coral reefs are being threatened, while pollution and overfishing have depleted many valuable ocean species.

than one-third of respondents knew that coral reefs were declining. Even in coastal communities, despite widespread reliance on fish, few people connected healthy coral reefs with the supply of food from the sea (211).

Oceans and Fisheries

Almost everywhere, coastal cities dump their untreated wastes into the sea, often creating virtual cesspools so thick with pollution that almost no marine life can survive. No place in the world's seas is immune, as ocean currents transport pollutants to the far corners of the world (269).

In the Gulf of Mexico an environmental "dead zone" now covers over 7,700 square miles and appears to be expanding. Agricultural and industrial pollution from the Mississippi River Basin is responsible (159). In Calcutta, Bombay, and other cities of developing countries, raw sewage and untreated municipal wastewater flow into coastal waters in large amounts (94). In Chile untreated effluents, mostly from copper mines, pulp and paper mills, fish processing plants, and oil refineries, flow directly into the Bays of Valparaiso and Concepcion (229).

Rapid population growth along coasts has boosted demand for fish, while mounting pollution has threatened marine habitats. Over 80% of all commercial fish are caught within 320 kilometers of land, and many within just 50 kilometers. A combination of over-fishing and pollution has contributed to lower productivity in all but 4 of the world's 15 major fishing regions (148). In the hardest-hit regions catches have fallen by more than 30% since as recently as 1989 (270). In Southeast Asia nearly all waters within 15 kilometers of land are over-fished (89).

According to FAO, 69% of the world's commercial marine fish stocks are "fully exploited, over-fished, depleted, or slowly recovering" (77). Two-thirds of commercially valuable ocean species are in decline and in urgent need of management (59). Landings of the most valuable species of fish, including cod, tuna, and haddock, have dropped by one-quarter since 1970 (149).

What Can Be Done?

In 1994 the Law of the Sea Convention established a foundation for sustainable ocean management. The Convention affords all states the right to manage marine resources within their 200-nautical-mile Exclusive Economic Zones (EEZs). Most developing countries do not have the means to enforce regulations over such a vast expanse of sea, however (3).

In 1998 the World Wide Fund for Nature (WWF) and the World Conservation Union (IUCN) prepared a blueprint for sustainable management. Their suggested approach involves six principles:

1. Plans for conserving marine biodiversity must take account of human needs.
2. Educating the public and raising awareness must play a role in better marine management.
3. Communities must have the opportunity to protect and manage their own coastal resources.
4. Social and economic incentives must be created for conservation and sustainable use of ocean resources.
5. Policies must reflect the fact that the world's oceans are connected.
6. Governments must take the lead in managing their own waters, while cooperating with neighboring states.

Coastal resources are not easy to manage. Around the world, 177 nations have coastlines, but only 92 have coastal management plans. While this number is nearly twice that in 1992, most countries have yet to move from planning to implementation (204, 205).

Forests—the Earth's Lungs

The world's forest cover is shrinking. Over the past 50 years nearly half of the world's original forest cover has been lost—some 3 billion hectares. Each year another 16 million hectares of virgin forest are cut, bulldozed, or burned (25, 76).

Between 1980 and 1995 the world lost some 180 million hectares of forest—an area the size of Indonesia. While developed countries had a net increase of 20 million hectares due to reforestation, this gain was more than offset by a net decrease of 200 million hectares in the developing world (76).

Forests have many functions of value both to humanity and to nature itself. Take away the trees, and the intricately linked ecosystem unravels (83, 162). Forests absorb carbon dioxide and produce oxygen, anchor soils, regulate the water cycle, protect against erosion, and provide a habitat for millions of species (59).

Forest products are essential to the world economy, worth about US$400 billion annually in timber, pulp, paper, and fuelwood. Forest products other than wood, such as medicines, vegetables, and fruits, provide another US$20 billion and are growing in importance (83, 162).

Healthy forests boost food production. Trees soak up and store water from season to season, slowly releasing moisture during dry periods. Without tree cover, water runs off faster during the tropical rainy season, carrying away valuable topsoil. A World Bank study found that the rate of soil loss was 10 times higher on forest lands where slash-and-burn shifting cultivation was practiced than in undisturbed forests (34). One reason that agricultural yields have fallen in sub-Saharan Africa is that vast amounts of forest cover have disappeared, hastening soil erosion and loss of soil nutrients.

Forest cover regulates climate, while destruction of forests contributes to global warming. Whereas living trees soak up and store carbon dioxide from the atmosphere, trees that are cut down and burned release carbon into the atmosphere. In the last decade tropical deforestation has released large amounts of stored carbon—accounting for roughly one-quarter of the carbon dioxide emissions to the atmosphere due to human activity (83) (see box, p. 16).

Pressures on Forests

Current demand for forest products may exceed the limits of sustainable consumption by 25% (83, 249). The developed world accounts for most of the demand for forest products. With just 16% of the world's population, North America, Europe, and Japan consume two-thirds of the world's paper and paperboard and half its industrial wood (2, 25). Demand for industrial wood products also has risen in developing countries, however, along with demand for fuelwood, the main energy source for many rural communities (76).

Throughout the 1990s many developing countries with rapid population growth had high rates of deforestation (58). Forest land was converted to agricultural use, and trees cut to provide housing and wood for fuel. Moreover, developing countries stepped up exports of forest products to meet the rising demand from developed countries.

The amount of forest area per capita fell by half between 1960 and 1995—reflecting both population growth and the disappearance of forest cover (83). In 1995 close to 1.7 billion people lived in countries with less than one-tenth of a hectare of forest cover per capita (83). By 2025, an estimated 4.6 billion people will live in such countries.

What Can Be Done?

As population grows and per capita consumption of forest products increases, countries must do more to manage forest resources on a sustainable basis. The following developments offer encouragement:

Haroldo Castro/Conservation International

In Brazil and many other developing countries, logging is an important source of revenue. Forests are essential to the world economy, but current demand for forest products may exceed the limit of sustainable consumption by 25%.

Technological improvements. Technological improvements, including use of recycled paper and paperboard, have substantially reduced the amount of pulp needed to produce paper. In 1970 paper and paperboard consisted of 80% wood pulp. By 1997 more efficient production processes had reduced that figure to 56%. As a direct result, the production of pulp for paper is expected to grow by just over 1% a year over the next decade, about half the growth rate in the 1980s (76).

Forest products certification. Adopting a system that identifies forest products that come from sustainably managed forests could support efforts toward sustainability. As of 1998, about 10 million hectares of forest lands have been certified (276). Over 90% of the certified area is in northern, temperate forests, mostly in Europe and North America. Close to 60% of the entire certified area is in just two countries—Sweden and Poland—reflecting education and awareness campaigns in those countries (76). In tropical forests, where most of the destruction is taking place today, only tiny areas have been certified as providing sustainable yield.

Intergovernmental responses. In 1995 the Intergovernmental Panel on Forests (IPF) was established in response to the 1992 Earth Summit. The IPF evolved into the Intergovernmental Forum on Forests in 1997, after the UN's five-year review of the Earth Summit goals. The mission of the forum is to examine the underlying causes of deforestation and to help countries develop strategies that address them (76).

Efforts to advance an international legal convention on forests, which began in 1990, have been shelved, however. Some observers believe that advancing such a convention would only codify the standards of a weak consensus and thus would be worse than no convention at all (15, 101). Widespread opposition to a convention makes it unlikely that the issue will reach the negotiating table (6).

Instead, many organizations urge governments of countries with large forest resources to enforce existing legislation and to introduce more effective forest conservation initiatives (6, 235). Close to 130 countries have developed or updated their National Forest Programs over the past decade (76).

While such initiatives are promising, they cannot be expected to halt forest destruction completely. Millions of people rely on forest products for their livelihoods. Sustainable forest management will require not just enforcement of laws that protect forests but also alternative sources of livelihood for many rural people.

Endangered Biodiversity

No one knows the true scope of biodiversity—how many species of plants and animals share the planet with human beings. Most estimates put the number at somewhere between 10 million and 30 million, with some consensus around the figure of 14 million (43, 56, 143, 163). In any case, only about 1.7 million species—a small share of the total—have been identified and categorized, while even fewer have been studied (162, 163).

Whatever the actual number of species, preservation of biodiversity itself is vital to humanity. Currently, over 40,000 species of plants, animals, fungi, and microbes are regularly exploited for human benefit (56). An estimated 40% of modern drugs come from the wild, worth some US$40 billion a year in over-the-counter and prescription sales (217).

Biodiversity is essential to agriculture. After 10,000 years of settled agriculture and the discovery of some 50,000 varieties of edible plants, just 15 food crops provide 90% of the world's food energy intake. Three of them—rice, wheat and corn (maize)—are the staple foods of 4 billion people (73, 75, 257).

Dependence on only a few crops can be dangerous because disease can spread rapidly through monocultures—as it did through the Irish potato harvest, starving one-fifth of the country's population in the 1840s (181). Cultivars (cultivated plants) need to be cross-bred every 5 to 15 years to give them greater resistance to diseases and insects, as well as to introduce new yield-enhancing traits, such as increased tolerance for drought or saline soils.

Heraldo Castro/Conservation International

Endangered species. Left: Sumatra rhino. Right: Madagascar lemur. Humans share the planet with at least 10 million other animal and plant species. Biological diversity is crucial to the world's ecology, and probably to the future of humanity itself. Yet human actions and numbers are sending thousands of species into extinction—most in areas where human population density is highest.

Without repeated infusions of new genes from the wild, geneticists cannot continue to improve staple crops. Since 1900 about three-quarters of the genetic diversity of cultivars has been lost, as well as nearly half of the wild gene pool of domestic animals (73, 217).

Human Exploitation

Humankind's current patterns of resource exploitation do not bode well for the future of biodiversity. Ecologist Norman Myers recently estimated that some 600,000 species have vanished since 1950 (164). Today, two of every three species are estimated to be in decline (216).

People today use almost half the energy needed to keep all of the earth's species going. That is, human beings use about 40% of the total net primary production of the earth's green plants, which are the fundamental food source for animals. This percentage could double within a quarter century (136). Over-exploitation of plants is worrisome, as plants provide the link to all other forms of life, through photosynthesis. "All flesh is grass," biologist David Given has observed (86).

The IUCN has reported that about 5,200 species of animals currently are threatened with extinction (115), including:

- Close to 1,100 species of mammals, one-quarter of the total number of such species;
- Over 1,100 birds, 11% of the 9,600 known species of birds;
- Over 2,000 species of freshwater fish, 20% of the total number identified;
- 253 species of reptiles, 20% of the total number surveyed;
- An estimated 124 species of amphibians, 25% of the total number surveyed (216).

Nearly 40% of all freshwater fish species in the US are at risk of extinction, as are 33% of Australia's freshwater fauna, and 42% of Europe's (18). Of the 514 species of birds in Europe, 270—about two-thirds—are threatened with extinction. Of these, 200 species are migratory (100). Many migratory species are threatened because of habitat destruction at both ends of their north-south migration routes (56, 115). Two-thirds of Asia's wildlife habitats have been destroyed, many over the past five decades (233).

Plant species are not faring well, either. Of the 270,000 known species of higher plants (such vascular species as trees and flowering plants), 34,000 are endangered (116). In the US nearly 30% of the 16,000 known plant species are at risk of extinction (17). In the tropics ecosystem destruction is so severe that some 60,000 plant species, roughly one-quarter of the world's remaining total, could be lost within 25 years (112, 217, 266).

Population Pressures on Biodiversity

Population pressures have played a major role in the loss of biological resources (9). Human activities have accelerated the normal pace of species extinction—that is, the pace that could be expected without the influence of humanity—by some 1,000 to 10,000 times, depending on the specific species (141, 246).

In a study of 50 countries in Asia and Africa from 1980 to 1990, the United Nations Population Fund (UNFPA) found that the loss of natural habitat was greatest in areas of high population density and least in low-density areas. In the 10 countries that had lost the most habitat (averaging 85%), the average population density was close to 200 people per square kilometer. In the 10 countries that had lost the least amount of habitat (averaging 41%), the average population density was just 29 people per square kilometer (95).

Lauren Goodsmith

A nurse tends medicinal plants. About 40% of modern drugs come from the wild. Biodiversity also is key to agriculture, as constant infusions of new genes are crucial to improving staple food crops.

Other researchers have reached similar conclusions (9, 43, 179). One estimate is that three-quarters of human-induced pressures on mammal species, and nearly two-thirds of such pressures on bird species, are the result of fragmentation and destruction of their habitats, as people use more land for agriculture, industry, roads, and other purposes (43).

Human migration and trade have posed other problems for biodiversity, as people have introduced many nonnative species to areas, such as Hawaii, whose fragile habitats cannot cope with them (19, 108). For example, the Black Sea's fauna have been nearly exterminated not only by overfishing and pollution, but also by the accidental introduction of a comb jelly fish from the North Atlantic, a species that now comprises about 95% of the Black Sea's biomass (19, 153). In the US the introduction of nonnative species has been implicated in close to 70% of all freshwater fish extinctions (216).

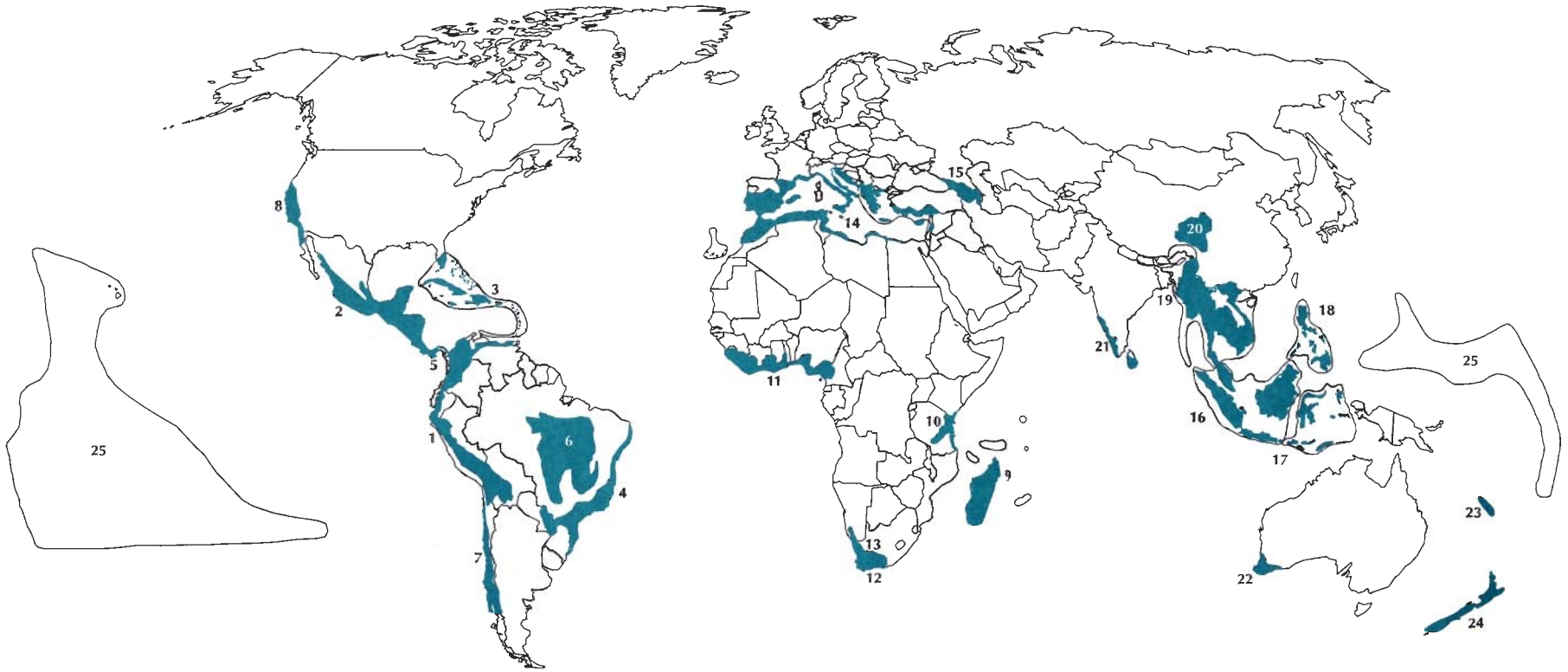
Biodiversity Hotspots

Biodiversity hotspots are areas that contain a superabundance of plant and animal species but are threatened by human activities. Norman Myers coined the term "hotspots" in 1988, initially listing 10 tropical rainforests (161). He later expanded the number of hotspots to 18, and then to 25. Collectively, hotspots contain slightly more than half of all terrestrial species on just 2% of the world's land area. Most hotspots are substantially endangered already, having lost three-quarters of their total original vegetation (155, 164).

So far, all hotspots identified are on land (270). Many hotspots remain to be assessed and identified in marine areas, especially coral reefs, which are thought to contain more than a million species living on less than 1% of the earth's surface (103, 270).

Of the world's 25 terrestrial hotspots, 9 are in tropical rainforests, 5 include both wet and dry tropical forests, and

The 25 Biodiversity Hotspots



1. Tropical Andes
2. Mesoamerica
3. Caribbean
4. Atlantic Forest Region
5. Chocó-Darién-Western Ecuador
6. Brazilian Cerrado
7. Central Chile
8. California Floristic Province
9. Madagascar and Indian Ocean Islands
10. Eastern Arc Mts. & Coastal Forests
11. Guinean Forests of West Africa
12. Cape Floristic Province
13. Succulent Karoo
14. Mediterranean Basin
15. Caucasus
16. Sundaland
17. Wallacea
18. Philippines
19. Indo-Burma
20. Mountains of South-Central China
21. Western Ghats and Sri Lanka
22. Southwest Australia
23. New Caledonia
24. New Zealand
25. Polynesia/Micronesia

Source: Cincotta and Engelman, 2000 (275)

another 5 consist of temperate Mediterranean-type ecosystems. In addition, three include tropical rainforest, dry forest, and arid systems; another is a mosaic of dry forest and savannah; while another is temperate forest and steppe; and the last is an arid region. An estimated 75% of all terrestrial animal species considered endangered or threatened live within these 25 hotspots (155) (see map).

The poor state of most biodiversity hotspots results directly from population growth and migration into these areas. A study by PAI found that by 1995 around 1.1 billion people, or 20% of the global population, were living within the 25 hotspots. Moreover, the average annual population growth rate in these areas was 1.8%, substantially higher than the 1.4% global rate and even above the average for developing countries, at 1.6%. PAI concluded that "human-induced environmental changes" will continue to put pressure on hotspots and, therefore, that conserving biodiversity requires paying close attention to population trends (35, 36).

What Can Be Done?

Scientists point to three actions in particular that could help protect biodiversity—and might even help ensure that human life on earth itself does not become extinct (9, 141, 163, 216) (see box, right).

Protect hotspots. As more organizations focus on protecting hotspots, the species within them might stand a better chance of survival. In 1989 Conservation International and the MacArthur Foundation became the first organizations to adopt the concept of biodiversity hotspots as a guiding principle for investments in environmental conservation (155). As new hotspots in marine areas are identified and added to the 25 currently identified terrestrial hotspots, protection should be extended to them, as well (270).

Safeguard protected natural areas from development. Over the past two decades population pressures and a shortage of arable land have forced some 200 million landless peasants out of traditional farming areas and onto protected land rich in biodiversity. These "shifted cultivators," as Myers has termed them, have little choice but to exploit the animal and plant species in these "biological oases" (164). To protect these natural areas, more must be done to help farmers settle on productive land, while stemming the future flow of population into protected natural areas.

Implement the Convention on Biological Diversity. This Convention, which was opened for signature at the Earth Summit in Rio, took force in December 1993 and so far has been ratified by 175 countries. The Convention has three major objectives: conserving biodiversity, ensuring its sustainable use, and guaranteeing the fair and equitable sharing of its benefits.

The US has rejected this third objective, as currently worded, largely because of the influence of the pharmaceutical industry. As a result, the US has not ratified the Convention and is unlikely to help implement it until agreement can be reached on how to compensate the US pharmaceutical industry for its bio-prospecting costs (6). Nevertheless, the Convention can be a major force for conservation, and the 175 countries that have ratified can do more to achieve its goals.

Five Extinctions and Counting

We live in the period of the greatest extinction of plant and animal species since the extinction of the dinosaurs some 65 million years ago (9, 56, 143, 246). The history of life on earth has included at least five periods during which huge numbers of species vanished forever, primarily due to changes in climate and sea level. Some scientists worry that a sixth extinction has begun because of humanity's gross misuse of the earth's resources (56).

First extinction: End-Ordovician. About 440 million years ago. This was the second-most severe extinction yet discovered. About 85% of all species were wiped out.

Second extinction: Late Devonian. About 365 million years ago. Marine species were particularly hard-hit in an extinction that took place in two waves a million years apart.

Third extinction: End-Permian. About 251 million years ago. With an estimated extinction of 96% of all species, this is the largest mass extinction of all. It dealt a near fatal blow to mammal-like reptiles that had ruled life on land for 80 million years. The dinosaurs stepped into their place as the dominant species.

Fourth extinction: End-Triassic. About 205 million years ago. An estimated 76% of all species, mostly marine creatures, vanished.

Fifth extinction: End-Cretaceous. About 65 million years ago. This is the most famous mass extinction of all because it signaled the end of the dinosaurs, which had dominated the land for 140 million years. Probably between 75% and 80% of all species disappeared during this time.

Sixth extinction? Since 1950 some 600,000 species have disappeared (164), and nearly 40,000 more currently are threatened (116). The pace of extinction may increase under the weight of human consumption and pollution of natural resources and, with global warming and resulting rising sea levels, take on alarming proportions.

Can we assume that life on earth as we know it can continue no matter what the environmental conditions? Or are we setting the stage for an eventual sixth extinction—our own?

Toward a Livable Future

Assuring a livable future requires practicing sustainable development. Enabling people around the world to meet their current needs without depriving future generations of the resources needed to meet their needs poses a challenge (259). Currently, humanity is using about one-third more of the earth's biological productivity than can be regenerated. To achieve sustainable development, people must learn, in effect, to live on the world's "ecological interest" instead of drawing down its "ecological capital" (see p. 4).

Debate continues about how best to accomplish sustainable development (6, 8, 91, 189). Nevertheless, in a number of areas, progress is being made. Particularly important are:

- Improving energy efficiency;
- Planning cities better;
- Ending environmentally destructive subsidies;
- Adopting water resources management;
- Saving forests;
- Accomplishing a second Green Revolution;

An Agenda for Change

The Rio Declaration on Environment and Development, adopted at the 1992 UN Conference on Environment and Development—the Earth Summit—expressed concern about the deteriorating status of the environment and established goals for improvement. The Earth Summit's "Agenda 21" publication set forth recommendations for change agreed to by the 179 countries participating. As the following excerpts from "Agenda for Change," a "plain-language version" of the Earth Summit document illustrate (125), the world community has endorsed ambitious and far-reaching goals. It now remains to adopt policies and take actions to reach them.

Population and sustainability. The world's growing population, combined with unsustainable production and consumption patterns, is putting increasing stress on air, land, water, energy, and other essential resources.

- Development strategies will have to deal with the combination of population growth, ecosystem health, technology, and access to resources. Meeting the unmet need for family planning and reproductive health services should be part of national sustainable development strategies.
- The world needs to do a better job of forecasting the possible outcomes of current human activities, including population trends, per capita resource use, and wealth distribution.

Protecting the atmosphere. The atmosphere is under increasing pressure from greenhouse gases that threaten to change the climate and from chemicals that reduce the ozone layer. Governments need to:

- Modernize existing power systems to gain energy efficiency and develop new and renewable energy sources.
- Promote national energy efficiency and emission standards and develop efficient, cost-effective, and less polluting mass transit systems.

Combating deforestation. Forests worldwide are threatened by uncontrolled degradation and conversion to other uses because of increasing human pressure.

- There is an urgent need to conserve and plant forests in developed and developing countries to maintain or restore the ecological balance and to provide for human needs.
- Governments need to work with business, scientists, local community groups, indigenous people, and the public to create long-term conservation and management policies for every forest region and watershed.

Sustainable agriculture and rural development. Hunger is already a constant threat to over 800 million people, while the world's ability to continue meeting growing demand for food and other agricultural products over the long term is uncertain. Soil erosion, salinization, waterlogging, and loss of soil fertility are increasing in all countries.

Agriculture has to meet rising needs mainly by increasing productivity, because most of the world's best croplands are already in use. At the same time, further encroachment on land that is only marginally suitable for cultivation must be avoided.

- Sustainable agriculture and rural development will require major adjustments in agricultural, environmental, and economic policies in all countries and at the international level.

Conservation of biological diversity. The loss of the world's biological diversity continues, mainly from habitat destruction, over-harvesting, pollution, and the introduction of foreign plants and animals (known as exotics). This decline in biodiversity is largely caused by human activity and represents a serious threat to our development.

Urgent and decisive action is needed to conserve and maintain genes, species, and ecosystems:

- Develop national strategies to conserve and sustainably use biological diversity and to make these strategies part of overall national development efforts.
- Implement fair sharing of the benefits between providers and consumers of biological resources.
- Protect natural habitats. Promote the rehabilitation of damaged ecosystems.

Protecting and managing the oceans. Oceans are under increasing environmental stress from pollution, over-fishing, and degradation of coastlines and coral reefs. About 70% of marine pollution comes from sources on land. Countries should commit themselves to control and reduce degradation of the marine environment. They should:

- Build and maintain sewage-treatment systems and avoid discharging sewage near shell fisheries, water intakes, and bathing areas.
- Develop land-use practices that reduce run-off of soil and wastes to rivers and thus to the seas. Use environmentally less harmful pesticides and fertilizers.
- Control and prevent coastal erosion and silting, due to land uses such as unplanned construction.

Protecting and managing freshwater. In many parts of the world there is widespread scarcity, gradual destruction, and increased pollution of freshwater resources. The causes include inadequately treated sewage and industrial waste, loss of natural water catchment areas, deforestation and poor agricultural practices, which release pesticides and other chemicals into the water. The following approaches are key:

- The way to provide all people with potable water and basic sanitation is to adopt the approach "some for all rather than more for some." This approach can be achieved through low-cost services built and maintained at the community level.
- Nations need to identify and protect water resources and see that water is used on a sustainable basis. They need effective water pollution prevention and control programs. There is a particular need for appropriate sanitation and waste-disposal technologies for low-income, high-density cities.

- Managing coastal zones and ocean fisheries;
- Curbing pollution, improving health;
- Safeguarding biodiversity; and
- Stabilizing world population

Improving Energy Efficiency

Using energy more efficiently is becoming one of the world's highest priorities and greatest challenges (50, 80). The 20% of humanity in the most affluent countries consume close to 60% of the world's commercial energy (222). Nonetheless, most industrialized countries use energy more efficiently than developing countries, which often do not have the means to invest in energy-saving technologies or pollution control measures (69, 222, 226, 261).

Since the oil crisis of 1973, developed countries have adopted energy efficient and cost-effective technologies. These technologies include more efficient heating and cooling systems, better insulation, and lighting and appliances that use far less energy per unit of output (69, 70, 248). Energy efficiencies also are rising as industrial processes become less energy-intensive and as electric utilities find that selling energy conservation—referred to in the industry as "negawatts"—pays (248). Switching to renewable energy sources, such as wind, solar, and geothermal energy, is another improvement in conservation. Renewable energy sources are increasingly competitive in price compared with fossil fuels, and they cause little or no pollution (60, 180).

The following actions also could help conserve energy:

- **Encourage the design and use of low-energy buildings** (69). In India, for instance, Development Alternatives, a nongovernmental organization, has designed a simple, adobe-like house that needs no air conditioning. It is made from specially designed blocks that permit airflow and a new roofing tile made from micro-concrete, free from chemicals and synthetic fibers (13).
- **Eliminate government subsidies for fossil fuels.** In 1991 direct subsidies for fossil fuels totaled US$220 billion worldwide. Eliminating these wasteful subsidies, paid for with public tax money, and offering tax incentives (subsidies) for wind- and solar-powered energy generation would encourage their development (70).
- **Encourage energy efficiency programs in industry.** Most industrialized countries have voluntary programs to encourage energy efficiency at work sites. Developing countries are starting such programs, too. China, for instance, has introduced worker bonuses for ideas that lead to more efficient energy use. Since 1990 these programs have resulted in savings of some US$6 billion through energy efficiency improvements, which have increased Chinese industrial competitiveness (69).
- **Invest in public transportation.** Encouraging public transportation as an alternative to individual vehicles in urban areas is difficult. But it is becoming increasingly needed as urban populations and vehicle use increase. Finding ways to get more people to use public transport would go far to reducing pollution and saving energy.
- **Introduce "hypercars."** Hypercars—vehicles that run 80 to 100 miles per gallon of gasoline (petrol)—already are available but have not been produced in large numbers because demand is lacking. Making such vehicles readily available would be a sound investment, perhaps promoted by offering government rebates for their purchase. They are especially needed in smog-ridden urban areas (248).

Planning Cities Better

Massive migration and rising population densities have made effective city planning and urban environmental management both a necessity and an increasing challenge. Effective urban planning and management require strong local government supported by active citizen groups (257).

Curitiba, Brazil, provides an example of effective urban environmental management sustained for over two-and-a-half decades. The World Bank has supported the Curitiba effort since the 1970s (214). Early in its planning process the city set aside large tracts of land and allowed poor squatters to build low-cost housing there. The city provided sewerage and water at a price that residents could afford (32, 156).

The city of Curitiba also introduced public transportation to link outlying areas with the city center through five primary roadways, built like spokes on a wheel. The result was less pollution and more economic growth, since people could travel farther to work by mass transit without as many private vehicles clogging the roads (32, 156, 171). In addition, Curitiba has achieved twice the amount of green area per person recommended by the UN (32).

Citizen action groups and nongovernmental organizations (NGOs) also can do much to improve living conditions. For example, in Orangi, a slum in Karachi, Pakistan, an NGO that mobilized the community was able to provide 70,000 households with sewerage and drains at one-seventh the unit cost that municipal authorities would have charged. The NGO also helped to obtain a low-interest loan to pay for the construction materials (198).

City governments also can enforce legislation that regulates air and water pollution. Nearly every city in the world has set limits on air and water pollution, but these regulations are rarely enforced. Clamping down on major polluters would yield many health benefits. Pollution control can be phased in to allow industries to adopt pollution abatement technologies and reduce waste through recycling or reuse of resources. Cities also could offer tax inducements for avoiding and for cleaning up pollution (198).

Curitiba, Brazil, provides an example of good urban management sustained for over two-and-a-half decades. Planning cities better in the face of rapid population growth requires strong government commitment and support from citizen groups.

D. Hinrichsen

Cassava plants in Northeast Thailand. A second Green Revolution in agriculture should focus on crops grown by the world's poor.

Ending Environmentally Destructive Subsidies

Worldwide, governments spend between US$650 billion and US$900 billion every year to subsidize environmentally destructive practices in agriculture, energy, and transportation (47, 196). Wasteful subsidies abound. Rice growers in Southeast Asia over-irrigate their fields because subsidies cover most of the costs of water, even though the amount of water used exceeds the natural recharge rate of many aquifers. Drivers in California use congested highways because road building and repair is subsidized more than public transportation. Uneconomical and highly polluting brown coal is still mined in Germany to keep miners employed (47, 195, 196).

As an alternative to wasteful subsidies, governments can consider the following:

Environmental taxes. Taxing activities that harm the environment can promote more sustainable resource use. In Malaysia the government began to tax leaded fuel to make it more expensive than unleaded fuel. As a result, unleaded gasoline has taken more than 60% of the market. Similarly, Costa Rica has placed a 15% duty on oil products in order to pass some of the costs of road construction on to drivers (195).

Tradable permits. Introducing permits to limit exploitation of public resources can help reduce waste. For instance, Chile has auctioned off permits to regulate fisheries and water use on irrigated farms. Nearly all of New Zealand's fisheries are regulated by permit systems that, among other things, limit the number of fishing vessels allowed to fish and also limit the types of species they can harvest.

The US has become a leader in tradable permits to control emissions of sulfur dioxide, a main ingredient in acid rain. The system, which was introduced in 1990, limits sulfur emissions after 2000 to half the 1980 level. Companies that reduce pollution below industry standards can sell credits to companies that are above the limits. This initiative created a US$1.2 billion a year industry in pollution credits and has spurred companies to reduce sulfur emissions (195, 196).

Getting the price right. Phasing out subsidies that encourage waste of resources should be a goal of every government. Getting the price right is a vital step in natural resource management, as in other sectors. A study of three oil exporting countries—Algeria, Iran, and Nigeria—found that removing subsidies to domestic use and bringing the price of domestic oil up to world levels would improve the efficiency of domestic oil use, resulting in savings of 10% to 18% of current production, which could then be sold abroad (47).

Adopting Water Resources Management

Increasingly, governments and NGOs are collaborating to promote integrated water resources management (IWRM) at the watershed or river basin level. IWRM is a comprehensive approach to regional management of surface water, groundwater, and coastal and marine aquatic resources. It not only addresses water conservation issues but also permits better management of human activities and land use affecting the quantity and quality of water resources.

Examples of integrated watershed management include the Chesapeake Bay program in the US, the Rhine River Basin initiative in Europe, and the Murray-Darling River Basin Commission in Australia. These programs have in common an alliance of state and national institutions in partnership with local citizen action groups and NGOs to manage common resources on a sustainable basis (1).

The following steps can help (102):

- Countries can first try water resources management within their own borders to gain experience and public acceptance. Coordinating conservation activities among different jurisdictions and at different levels of government, while balancing the often-competing interests of various water users, is complex.
- After successes on a small scale, the initiative can be expanded. An incremental approach is best—first tackling identifiable sources of pollution before moving to more difficult issues such as controlling the runoff of agricultural chemicals and animal wastes into rivers and lakes.
- Periodic benchmarks and reviews can help maintain public interest and acceptance and can measure progress.

Saving Forests

Community efforts to preserve forests and to manage forest resources are showing a way forward in some endangered areas. Successful efforts allow people to meet their immediate economic and household needs while safeguarding forest resources for sustainable use in the future (109, 121, 162).

For example, in Papua New Guinea, the Bainings people of New Britain have resisted commercial enterprises that want to log their forests. Instead of the usual clear-cutting approach, they practice a form of selective logging, harvesting only certain species of trees from particular forest plots. Once the most economically valuable trees have been removed, the area is left to regenerate (10).

Also, in the Talamanca Mountains on the border between Panama and Costa Rica, AMISCONDE, an NGO, helps 9,000 small-scale farmers increase yields on marginal land while preventing deforestation. AMISCONDE provides the farmers with loans and credits to improve yields on their existing farmland, rather than clearing forests to create new farmland, and to diversify their crops. The community now has a sense of ownership over forest resources that encourages conservation and stewardship (16).

At the international level, the Forest Stewardship Council, which was formed after the 1992 Earth Summit in Rio, links foresters, indigenous people, NGOs, forest products certification organizations, and timber traders in 25 countries. Its goals are to ensure that forests are managed in an environmentally appropriate manner, are socially beneficial to local communities, and are economically viable (2, 118).

Accomplishing a Second Green Revolution

The first Green Revolution in agriculture of the 1960s helped food production keep pace with population growth. Because population growth continued, the Green Revolution was only a "temporary success," said Norman Borlaug upon receiving the 1970 Nobel Peace Prize as one of its architects. Today, as population moves toward 8 billion in 2025, a second Green Revolution should focus on the food crops grown by the 2 billion people who lack food security (see p. 9). It should concentrate not only on improving the yields of the big three staples—rice, corn, and wheat—but also on such crops as sorghum, millet, and cassava (73, 75).

The World Food Summit, held in Rome in 1996, also recommended the following actions to improve agriculture:

Improving yields on marginal land. Despite poor quality soil and insufficient water, many marginal lands can be farmed successfully. For instance, the International Institute of Tropical Agriculture has pioneered "alley farming" as a sustainable substitute for slash-and-burn cultivation. If crops are used in the right combination, alley farming can greatly increase yields on poor soils in hilly regions and thus reduce the need to clear forests for farmland (114). The concept is simple: leguminous crops, such as mucuna, are planted between rows of food crops, such as peas and beans. The legumes help hold the soil in place and improve nutrient content while preventing weeds from taking root.

Expanding aquaculture. Where fish farming for local or regional consumption has been tried, the results have been impressive. Unless fish farms are well managed, however, they can contribute to coastal pollution, through improper disposal of wastes and over-stocking (77, 99).

Rediscovering forgotten foods. Another way to help achieve food security is to cultivate traditional food plants that modern agriculture has neglected. Amaranth and quinoa, two grains grown by the ancient Aztecs of Mexico and Incas of Peru, are examples. Both grains are versatile and nutritious, containing more high-quality protein than most other commercial grains, including corn and rice. Moreover, both grow well under difficult conditions. Amaranth thrives in hot climates, while the quinoa plant is frost-resistant and can be grown at high elevations (257).

Increasing yields. Some countries are improving crop yields with new approaches that use low-level inputs. Examples include fertilizing with animal wastes instead of chemicals, recycling nutrients, conserving water, and selecting a variety of crops better suited to soil conditions and climate (73, 75).

Another technique is Integrated Pest Management (IPM). IPM uses several related strategies: preserving natural pest predators, using pest-resistant seed varieties, and drastically cutting amounts of pesticides. This approach has increased yields while reducing use of pesticides and fertilizers (73).

Empowering women farmers. Women grow 80% to 90% of all food consumed locally in many developing countries. Women farmers need better access to credit, agricultural extension services, and training (72, 188, 219, 241).

Managing Coastal Zones and Ocean Fisheries

Better coastal management can help protect such ecosystems as mangrove forests, seagrass beds, and coral reefs; can protect coastlines from over-development; and can preserve fisheries and marine biodiversity. The following initiatives are promising:

- **UNEP's Regional Seas Program** needs international and regional support. It is one of the few working mechanisms in place that enables coastal states sharing the same body of water to work together on management issues.
- **The International Coral Reef Initiative**, launched in 1995 by eight countries, deserves high priority from NGOs, funding agencies, and the UN system. This initiative is one of the best examples of international and intergovernmental cooperation to address the decline of the world's coral resources.
- **The Code of Conduct for Responsible Fisheries**, which FAO launched in 1995, needs the endorsement of fishing nations and national laws to give it force. The code addresses fisheries management and operations, aquaculture and mariculture development, and integration of fisheries management into coastal area management programs, among other areas. More than 60 fishing nations have agreed to this voluntary code, but it needs legal foundation in each country (149).
- **The UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks,** which FAO put forth in 1995, prescribes a cautionary approach to fishery management, both inside and outside Exclusive Economic Zones (EEZs). As of 1999, however, only 4 of the top 20 fishing nations had ratified it. It requires 30 signatures before taking effect (149).
- **The Law of the Sea Convention,** which came into force in November 1994, could become a more effective mechanism for regulating coastal and near-shore activities. It permits all coastal states to manage their 200 mile EEZs. Littoral states must enact and enforce fisheries restrictions, safeguard biologically diverse areas, protect more marine areas, and enact and enforce legislation that protects coastal waters from land-based pollution (102).

D. Hinrichsen

In India a scientist examines replanted pines in the Himalayan region. Forest management works best when it allows people to meet current economic needs while encouraging sustainability.

Curbing Pollution, Improving Health

Many steps that conserve natural resources and protect the environment also improve public health by curbing pollution. In particular, the following steps deserve attention:

- **Provide safe water** to the 1.2 billion people who lack access to this foundation of good health and well-being.
- **Provide adequate sanitation** to the 3 billion people who currently lack it. Breaking the water-borne disease cycle is fundamental to public health. In particular, curbing untreated sewage would help control the spread of water-related diseases.
- **Prevent air pollution** by reaching regional agreements that would improve air quality. Such agreements would give impetus to national and urban efforts to stem air pollution. One workable example is the Long-Range Transboundary Air Pollution Convention, endorsed by the Economic Commission of Europe (ECE), to curb acid rain and long-range pollutants.
- **Adopt a globally binding treaty to eliminate POPs.** Governments and NGOs can support UNEP in designing an international treaty that will phase out these dangerous chemicals as quickly as possible.

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In Bangladesh a field worker discusses family planning with women in their community. Fertility rates have fallen in many countries, but the world's population continues to rise rapidly.

Safeguarding Biodiversity

Trying to save species one at a time is a losing strategy. Instead, conservation must focus on biodiversity hotspots—the habitats in which most species live (162–164, 228, 252, 267) (see p. 22). The fact that these habitats are highly concentrated suggests that species conservation is much less expensive and potentially more effective than previously thought (29, 155).

The Convention on Biological Diversity should be implemented as quickly as possible. It is the one global agreement in place that can help preserve biological diversity. The convention recognizes community rights to wild biodiversity. Signatory countries are to set up a system of benefit sharing to compensate communities for the use of biological resources and related knowledge by pharmaceutical, biotechnology, and agricultural companies.

Stabilizing World Population

The last four decades have witnessed a profound change in fertility rates and world population growth. The transition from high fertility and high mortality to low fertility and low mortality (the demographic transition) has been substantially completed in the developed world and is underway in most of the developing world. Nevertheless, in many countries of sub-Saharan Africa, the Near East, and South Asia, population continues growing at 2% a year or faster, and the average woman bears four to seven children (182).

Thus it is important that the fertility declines that have characterized the past 40 years do not stall. Even small increases in fertility rates—which could occur if commitment to providing family planning information, supplies, and services were to diminish—would mean faster population growth. "Investments in measures to slow the rate of population growth—and thereby to reach a stable population earlier, and at lower levels, than under current trends—would significantly reinforce efforts to address the environmental challenges of the century ahead, and considerably lower the cost of such efforts," according to Richard Benedick (11).

Today, most women and men want to plan their families (245). The extent to which policy-makers and reproductive health care providers offer good family planning information and services will determine whether people will be able to have the number of children they want, when they want them. In the balance is whether the world's population could eventually stabilize at 9 billion or less, or whether it will grow to 11 billion, and even beyond (58, 84, 243).

Timing matters. Largely because fertility has been high, in some countries young people just entering their reproductive years comprise as much as half of the population. The childbearing patterns of these 2 billion people now under age 24 will determine whether population continues growing rapidly or slows to a more sustainable pace in relation to development and the environment. (243).

Funding matters. Developing countries account for most spending on family planning and other reproductive health care (242). While the number of people needing services has risen, public spending on reproductive health care has dropped significantly since 1995—the peak year for investments in reproductive health.

Most donor countries have not kept the commitments to population and reproductive health assistance that they made at the UN International Conference on Population and Development (ICPD) in Cairo in 1994. According to their commitments, developed countries should have invested US$5.7 billion a year in population programs by 2000 (242). Instead, the donor community has provided about US$2 billion annually. Currently, spending on global population programs amounts to less than half of the funding agreed to—around US$8 billion instead of US$17 billion.

Worries about a "population bomb" may have lessened as fertility rates have fallen, but the world's population is projected to continue expanding until the middle of the century. Just when it stabilizes and thus the level at which it stabilizes will have a powerful effect on living standards and the global environment. As population size continues to reach levels never before experienced, and per capita consumption rises, the environment hangs in the balance.

Most photos in this report were selected from the Johns Hopkins Population Information Program's Photoshare database of photos for nonprofit educational use at http://www.jhuccp.org/mmc/index.stm

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